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An assembly conveyor not only carries the work from one man to the other, but makes it possible for the men to specialize on certain operations.

Methods of Solving

Material Handling Problems

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ALL operating men do not have the same conception of what can be done toward lightening the burden of material handling in the average industrial plant. For example, in many instances practically all of the attention is given to the possibility of using some other or larger machine or equipment for doing the handling when much greater, as well as more important and worthwhile gains, would result from as close a study of the possibilities of entirely changing the plan of handling.

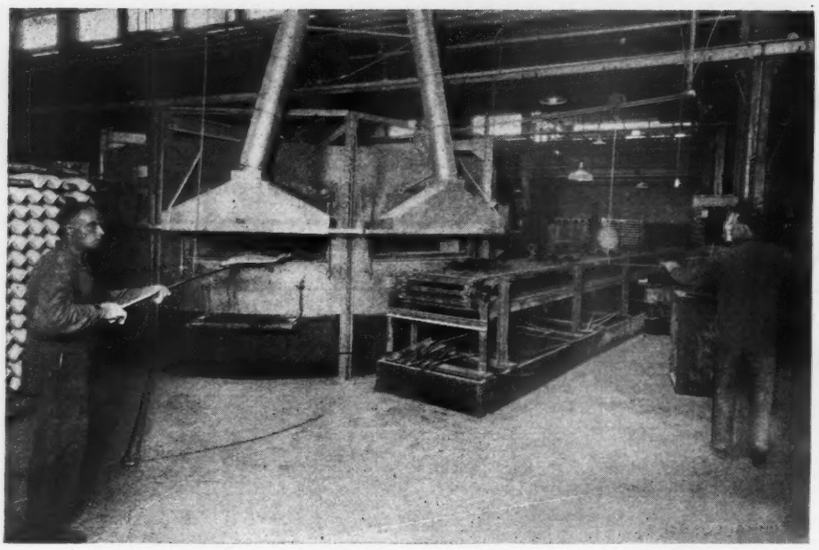
Material handling has a much broader meaning than the movement of materials into and out of stock and to and from machines. Increasing the size or quantity of units handled at a time is one method of improvement; another is to tie the handling in with the process, or to combine several steps of a process to eliminate handlings between steps.

Many plants are adding considerably to their handling costs by many needless rehandlings. However, the wide use of the lift truck and platforms has done much to eliminate this last item of waste.

Some of these points can best be explained by picturing the steps we have taken to overcome difficulties in handling materials of various kinds.

Our main plant is engaged in the manufacture of electric ranges and refrigerators, which are largely of sheet metal construction and are rather bulky when assembled, and of the line of Hotpoint electric household appliances, such as electric irons, heaters, and so on.

Before going further, it may be well for me to explain our policy regarding the purchase of material handling or other devices or equipment, which might be termed specialties. We do not believe in spending money for such equipment unless it will save its cost in a very short time —within a year or less—because there



This shows circular enameling oven with cooling conveyor.

Legs for ranges and refrigerators are placed in a circular oven by the man at the left. The man at the right moves them after they have made a complete revolution and places them on the slat conveyor at the right for cooling. This oven is operated by a Reeves variable-speed drive through a Foote worm speed reducer, which permits a wide variation in the length of time different products remain in the oven.

is so much equipment that may be purchased, or devices that may be made, which will save their cost in less than a year. We have always found enough of these items obtainable to use up all our appropriation. Naturally, the opportunities for investments with such quick returns are becoming scarcer and consequently we are increasing the limit. This policy, of course, does not extend to machine tools or other necessities for production.

Material handling begins with the receipt of the raw material, although we have found that many of the largest savings can be made during the manufacturing processes. Strip steel is received in boxes and is handled from the car to the storage warehouse on a short length of gravity roller conveyor. A hoist on an oval monorail track is used to pile the boxes in two rows, one under each of the two sides of the oval. The boxes are not turned as received, but go straight into the stockroom from the car and are moved to the right or left into position on the pile by the hoist, which is also used for lowering these boxes from the top of a high pile onto the lift-truck platforms when they are to be distributed to the various machines.

Larger sheets of steel are loaded loose from the cars on to short lengths of portable gravity roller conveyors which carry the sheets directly to the pile. It is thus necessary for the men only to straighten the sheets on the pile as they come off the conveyor. Handling, that is lifting and carrying, is practically eliminated.

The cost of these roller conveyors is practically nothing compared to what they will save in the cost of handling even a few carloads of steel, if the steel had to be carried the same distance, or loaded, hauled, and unloaded.

The sheet steel is handled to the various machines on Barrett-Cravens hand-lift trucks with extra long platforms. In addition, these hand-lift trucks are used practically altogether for handling material between machines, to inspection, and to the storeroom. We never unload a platform unless it is absolutely necessary to do so. Most of the work in process is transported in tote boxes because extra platforms to hold these are much cheaper than the rehandling which a shortage of platforms would entail.

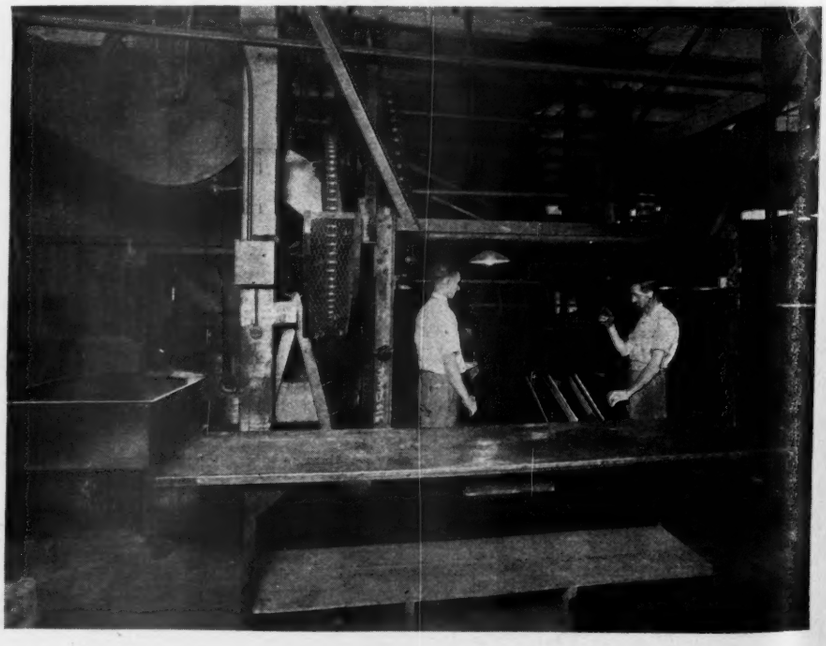
We are standardizing on a single size of tote box which, I believe, will also simplify our handling problem. At present we have two sizes. The larger is too heavy to handle in and out of shelf storage when filled. When all of the larger boxes are worn out, the spacing of the steel shelving will be changed to fit the smaller box and the quantity of each item placed in a tote box will be standardized to the quantity of that unit usually issued at a time, so that the stores department can issue parts for assembly by the tote-boxful without stopping to recount, which makes considerable saving in time.

Some of the work, particularly that with a finished surface, is handled on platforms or trucks with a special superstructure. One of these is shown at the left in the illustration of the circular enameling oven, on this page.

Large savings have been made

The discharge end of the japanning oven.

Parts which can be japanned by dipping are hung on a crossbar of this conveyor at the other end of the oven. The conveyor zigzags up and down and carries the parts through the benzine cleaning tank, through the japanning tank, and into the baking oven. Provision is made for attaching parts which must be baked but cannot be dipped. This conveyor, although one of the most expensive pieces of equipment in the plant, paid for itself in less than seven months.



through the elimination of handlings and rehandlings between the manufacturing operations and processes. Much of this has been done by tying together several related steps in the manufacturing operations, generally by means of some type of conveying equipment.

An example of this was the installation of a continuous belt to carry the sole plates (the heavy bottom plates) in electric irons, past an automatic drilling machine, and then past an automatic tapping machine. This belt extends about 3 ft. at each end past the machines, which gives sufficient operating space for one man to insert sole plates at one end of the belt and remove them at the other.

With a shorter belt two men, one at each end, would be required and the machining operations could not be speeded up any faster. In other words, there would be very little saving, because two men could operate the two machines almost as fast. The saving is obtained in the elimination of one operator and the handling *from* the first machine and *to* the second machine, practically one-half of the total handling.

The more steps that can be tied together, the greater is the saving. Of course, as the length of this belt is increased, a point is soon reached where one man cannot take care of both ends but, at the same time, a larger number of handlings should be eliminated or the device will not pay for itself.

One of our most expensive pieces of equipment in first cost and, incidentally, the one making the largest saving, is built on this same principle. This is the continuous japanning equipment, the discharge end of which is shown in the illustration on page 398. Even as expensive as this unit was, it paid for itself in about seven months.

This unit consists of a large Link-Belt roller chain conveyor built to carry the parts to be japanned, which are hung on crossbars. Instead of the parts traveling in a straight line, the conveyor is constructed to zigzag up and down. Although the total length of the conveyor on the floor is but 150 ft., the parts are carried about 225 ft. at a speed of 2 ft. per minute.

Parts which can be dipped are hung on a crossbar which is picked up by the conveyor, carried up and then lowered into the benzine cleaning tank. They are then zigzagged up and down into the drying chamber, where they are dried in warm air. From there they are passed up and down into the japan tank and from there are conveyed to the dripping chamber.

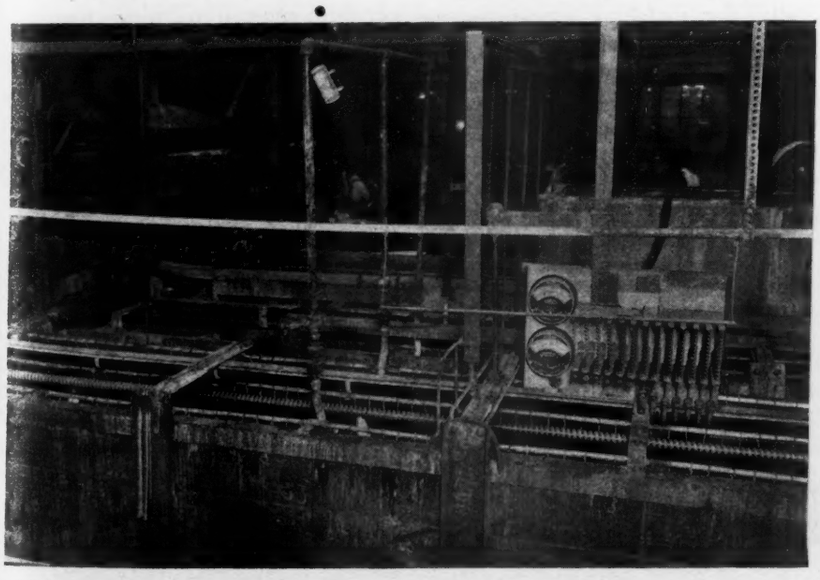
The chain then passes down near to the floor level to pick up parts that cannot be dipped, such as ovens that are sprayed with japan on the outside only, and then on through the baking oven, which is kept at a temperature of 450 deg. F. The benzine tank is protected by Fire-Foam sprinkler heads located over the center of the tank, with other heads on each side. A rapidly rising temperature in the benzine tank would open these heads, discharge the Fire-Foam and smother the fire.

The only handling required is in loading and unloading the conveyor, in contrast to the handling between the steps which would be necessary if this equipment and the various processes were not tied together in this way. In addition, a much larger amount of space would be necessary for storage between operations.

This conveyor is driven at constant speed by a high-speed motor through a belt, a Foote worm speed reducer and two roller-chain reductions. The chain on the conveyor is kept lubricated by a wiping lubricator. A

Special facilities are provided for handling refrigerator bodies during assembly.

For example, the inclined turntable at the right is used when welding seams so that the operator can turn the refrigerator easily during the welding process. Barrett-Cravens hand-lift platform trucks are used to handle heavier material throughout the plant.



Handling material in the plating room.

Parts are cleaned before plating, while on the special conveyor which alternately dips the parts and allows them to drain. Thus the only handling involved is in placing the parts on the conveyor at one end and taking them off at the other. The parts, still on the hooks, are then hung on the screw conveyor in the plating tank. The rotating screw carries them the length of the plating tank in 12 min.

special japanning-oven lubricating oil, which will stand up in the high temperature, is used.

The cleaning baths in the plating room are also operated in conjunction with a zigzag conveyor which carries the parts in and out of the cleaning and washing solutions. Handling in and handling out between the operations is thus taken care of automatically. This cleaning conveyor is driven at a constant speed by a motor belted to a Foote worm speed reducer.

The parts are removed from the last cleaning tank and hung on a rotating worm screw which carries them through the plating solution, as shown on page 399. These screws are driven through gears at a speed which will carry the parts the full length of the plating tank in 12 min.

Industrial men who have never had any experience with assembling on conveyors cannot appreciate their full worth. The illustration at the head of this article shows a part of our electric range assembly conveyor, which is 205 ft. long. This is a Palmer-Bee slat conveyor driven through a Palmer-Bee worm reducer by a variable-speed motor. Four speeds may be obtained through a drum controller which will drive the conveyor 10 ft. in 7.6 min., 5.2 min., 3.8 min., or 2.5 min. respectively. The speed is selected according to the model of range being assembled, the scheduled output, and the number of men working on the assembly line.

This method of assembly has been used in automotive and many other lines of industry and has been described so often that it will not be elaborated on in detail here. However, plants which have products adapted to assembling on conveyors will find this method one of the biggest savers of handling time. The work simply passes from one man to the next without his having to pick it up, set it down, or even move it, except at a few places in the assembly where the work must be turned. The amount of time spent in picking up work and setting it down is seldom realized until it is actually measured.

The circular vitreous enameling oven, also illustrated on page 398, makes the handling of work in and out a continuous process instead of the intermittent operations of loading, waiting until baked, and then unloading, with the oven idle during the loading and unloading time and the men idle during the baking time.

This oven is driven by a Reeves variable-speed transmission through a Foote worm speed reducer to give a variation in the time of rotation from 1½ min. to 9 min. so that it is adaptable to a large variety of work.

The enameled parts are removed from the conveyor and laid on the slat conveyor at the right to cool.

This conveyor travels at a speed of 6 ft. per min. and by the time the parts reach the end, they have cooled enough to be handled with asbestos mittens.

Use of Welding in Resurfacing Wearing Parts to Resist Abrasion

ABRASION is one of the most serious problems for industrial opearting and maintenance executives in many industries. This is particularly true in such industries as cement manufacturing, where metal parts of pulverizing, grinding, crushing and conveying machinery are worn out in a short time through abrasion. In a paper presented recently before the New York Section of the American Welding Society, A. V. Harris, Haynes Stellite Co., New York, N. Y., gave some interesting details of the results obtained by several plants in this industry that have successfully tried welding a coating of Stellite on the wearing surface.

Stellite is not a steel, but an alloy of cobalt, chromium and tungsten, and is produced in an electric furnace. It is a hard metal that resists abrasion, heat and corrosion, requires no tempering, and is cast to form; it can be finished only by grinding. This metal is widely used in cutting tools for machining metal.

Recently, however, considerable attention has been given the use of Stellite for surfacing in maintenance work, and a number of practical applications have been made of depositing it by means of welding equipment, on a surface subject to abrasion. It is said that it can be applied without heat treatment to copper and to any grade of steel, including carbon and alloy steels, and to practically any cast-iron surface.

For this coating or Stelliting, as the process is called, the alloy is provided in the form of welding rods. The surfacing, however, calls for a slightly different technique than most acetylene welding in that the process is neither welding nor brazing in the ordinary sense of these terms. For example, when welding, the surface of the base metal is brought up to the flowing point and the Stellite welding rod is then puddled and fused with the molten base metal.

Stelliting calls for blowpipe flames that contain a fairly large excess of acetylene to lower the flame heat and to exclude as much atmospheric oxygen as possible. The surface of the base metal to which the Stellite is to be applied is brought up to such a heat that it just begins to sweat and assumes an oily appearance. The lightest possible penetration into the parent metal is most desirable, since this eliminates the possibility of an undesirable alloy being formed with the Stellite.

At this point the Stellite is melted from the rod and allowed to flow on to the base metal with as little agitation as possible. The action when flowing on to the steel is similar to that of solder flowing from an iron on to a tinned surface. Examination of a Stellite weld made in this manner shows that practically no penetration into or alloying with the base metal has occurred. This coating may also be applied with the electric carbon or metallic arch process, it is stated.

Stellited metal parts, when used in pulverizing, grinding, crushing and conveying machinery in the portland cement industry, have a greatly increased life. A screw conveyor of the conventional type when coated on the periphery has, it is said, lasted six times as long as a heat-treated carbon-steel screw. A special surface ⅛ in. thick on a gudgeon as used in the cement plant will give that part a life three times as long as ½ in. of steel.

Hot drag chain supports, conveyor buckets and cams, steam shovel dipper teeth and roll mill plows may also have their life increased by thus coating the wearing surface. The combination properties of resistance to heat and resistance to abrasion are utilized in hot-drawing and hot-forming dies with an increase of three to five times in their life. The die is called upon to resist the heat of the metal that is being formed and the abrasion of this metal as it is drawn.

In the manufacture of dry cells or dry radio batteries a number of dies and machine parts come in contact with active chemical compounds that tend to corrode and destroy the metals used. Their life by coating may be increased because of the ability of this alloy to resist corrosion as well as abrasion.

Speed Reducers

Some of the inherent limitations that must be considered when applying these devices to industrial power drives

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UNIVERSAL use of the electric motor in the industrial plants of today has brought with it many innovations. This source of mechanical energy is compact, efficient, and applies the power at the point needed, but it has the inherent characteristic of operating at comparatively high speeds. In many cases these speeds are entirely too high for industrial purposes, and consequently some medium must be interposed between the motor and the driven machine that will step down the high motor speeds to the more suitable operating speeds.

This is admirably accomplished through the aid of a modern speed reducer. Of the many types of this equipment on the market at present, the most popular are the worm-gear and spur-gear types, although the herringbone type is preferred for the larger and heavier drives. These various types have been largely standardized so that they are available in suitable sizes and ratios for almost any power and speed reduction required.

It is the purpose of this article to point out the inherent limitations of these devices so that a prospective user of this equipment may make a proper selection to suit his particular requirements.

The trade catalogs in most cases list the ratios and the ratings, that is, the horsepower and speed, for which the speed reducer is designed. In a large majority of cases the rating represents the power capable of being transmitted when the materials of which the machine is composed are stressed to the maximum safe stress allowable; consequently no reserve for shock, overload, reversals or loads from outside of the machine exists, and the unit should be selected with a factor of safety which naturally varies with each individual installation. The question of efficiency also enters into the selection of a speed reducer, as there is no means yet extant of transmitting power without some power loss. It may be said that, in general, the greater the reduction, the greater the power loss.

One of the most important factors in the successful operation of a speed reducer is the connection to the motor, as well as the connection of the slow-speed shaft to the shaft of the driven machine. Flexible couplings are of paramount importance at these points. It is virtually impossible to line up two shafts, each supported on its own bearings, so that both will revolve about the same axis. Unless a flexible coupling is used, between the shafts, the bearings on motor, speed reducer and driven machine are subjected to extremely severe loads, for which they were not actually designed.

A flexible coupling is also subject to abuse; it should be applied only to shafts that are as nearly in line as possible. Where this condition does not exist a universal joint should be used. However, the arrangement employed by one user should be avoided: A flexible coupling was used between the speed reducer and the driven shaft, according to the manufacturer's recommendation, but a spur pinion was mounted next to the coupling and only one small bearing was provided on the other side of the pinion. The final result—early failure—was a foregone conclusion.

One of the most popular types of speed reducers is the worm and worm-gear type. This has been developed to a high state of perfection, so that the prevalent conception that a worm drive is inefficient has been entirely exploded.

The efficiency of such a drive is entirely dependent on the helix angle of the worm. The greater the angle (up to about 42 deg.) the greater the efficiency and, vice versa, the smaller the angle, the greater the power loss. This fact was not generally recognized in the early days by the industry, and accounts for the disrepute into which the worm drive fell.

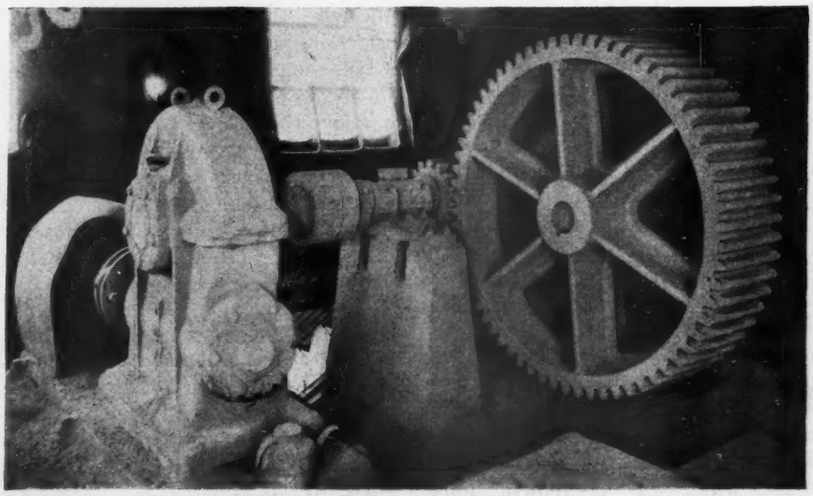


Fig. 1—This shows an auxiliary pinion shaft connected to a worm gear speed reducer in a cement plant.

The first reduction in speed is made by the worm gear reducer. A pinion mounted on the auxiliary shaft, which is coupled to the low-speed shaft of the reducer, drives the large gear and gives the second reduction in speed. This arrangement is often used to obtain greater speed reductions than can be efficiently secured by the use of the speed reducer alone. Note that the pinion shaft is supported in its own bearings.

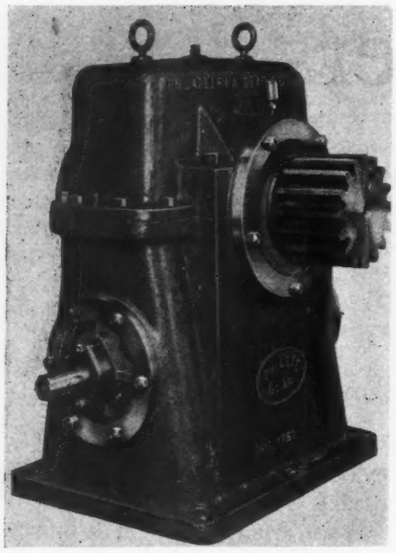


Fig. 2—Here is a worm speed reducer with a pinion on the low-speed shaft, making unnecessary the use of an auxiliary pinion shaft.

A pinion should not be mounted on the low-speed shaft of a speed reducer unless the bearings have been designed for this service.

Generally, all manufacturers of this type of drive strive to use as steep a helix angle as possible in their drives. However, in case this is not done, principally for economic reasons, such as the cost of providing new cutting tools, and so forth, a somewhat less efficient drive is the result. To cover up this defect, an extremely large and heavy casing may be provided for the drive so that the wasted power, manifesting itself in heat can be easily dissipated into the surrounding air.

Although it is possible to obtain extremely large reductions with this type of drive the power loss in the higher reductions precludes their economical application. Ratios of 60 or 70 to 1 are common, but beyond that point the efficiency drops very rapidly. To obtain higher reductions and still retain the right-angle feature of these drives two expedients may be used. The first and more common one is to provide an anxiliary shaft supported on its own bearings as shown in Fig. 1, upon which a pinion driving a gear is mounted. This shaft must be suitably connected to the final shaft of the speed reducer. Another more recent method is to employ a speed reducer especially designed with suitable bearings as in Fig. 2, to permit the mounting of a pinion directly on the slow-speed shaft. In any case, the manufacturer of the speed reducer should be informed of the conditions under which his equipment must operate as his experience has taught him what may and what may not be done with a successful drive.

A manufacturer of this type of equipment also has a good many requests for a worm drive which is to be self-locking; that is, it will not allow the load to run back when the power is shut off. There is nothing exceptionally difficult about this and a machine is made to conform to the user's specification. However, when the machine is put into service the manufacturer usually receives frantic telephone appeals to save the machine from burning up. The heating that is causing so much concern is due to the fact that a self-locking worm is inherently inefficient and at least 50 per cent of the power input is wasted in heat. As the reducer has only a limited amount of radiating surface the temperature rises to a critical point in a very short time. At this high temperature the viscosity of the lubricating oil is broken down; consequently metal-to-metal contact takes place between the worm and gear.

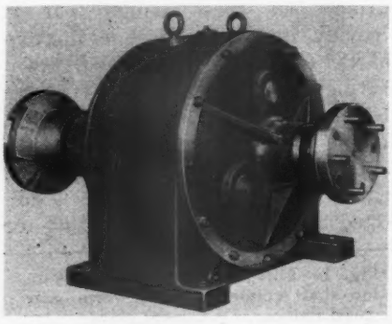


Fig. 3—Spur-gear reducer with flexible coupling connection.

This is a planetary type of speed reducer, which type has the advantage of giving the largest reduction possible in a small amount of space.

Before this point is reached let us hope that the drive is shut down; otherwise the consequences will be distressing and costly.

The remedy for this heating is to run the worm at a slow enough speed to allow the casing to dissipate the heat to the surrounding air, or to water-cool the drive. The latter expedient is, of course, a rather unsatisfactory solution. When a continuous direction of rotation is desired and it is merely necessary to hold the load in case of failure of the power, a more successful expedient is to employ what is commonly known as a backstop. This effectively prevents any backward movement of the load, in fact limiting the backward movement to the actual backlash in the gears. This feature was especially developed for grain elevator use and has proven very effective in service.

Likewise, the user should not expect a worm drive to operate without oil. The oil best suited for its use is specified by the speed reducer manufacturer and the maximum of service and economy can be expected only by its use. Very often it is assumed by the purchaser that the reducer has been shipped with the proper amount of oil in it. This is impracticable for obvious reasons. An aggravated instance of this came to the writer's attention some years ago, when a speed reducer was placed in operation not only without oil, but in addition was located next to a furnace where the surrounding temperature was in the neighborhood of 300 deg. F. Under these conditions the drive was worn out at the end of a week. Of course, the gear manufacturer was to blame!

Another design of speed reducer having peculiarities of its own is the spur-gear type, which is readily classified into two distinct groups; the planetary and the non-planetary type. Both types have certain advantages.

The non-planetary type usually consists of spur gears radially disposed about a central pinion. Each of the spur gears is keyed directly to pinions which in turn mesh with a central gear mounted upon the slow-speed shaft. This arrangement has the advantage of giving comparatively low reductions and keeping the rotational speeds at a minimum.

On the other hand, the planetary type, shown in Fig. 3, has the advantage of giving the largest reduc-

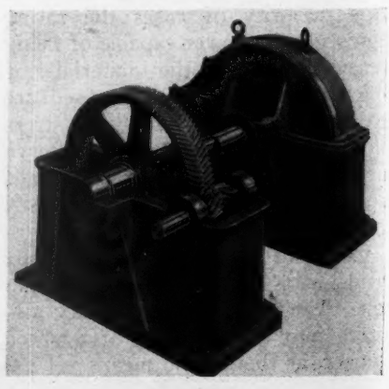


Fig. 4—Single-reduction type herringbone speed reducer.

Owing to the fact that the high-and low-speed shafts are offset, but parallel, this type of reducer requires more floor space than any of the other types described in the text, although it has the advantage of being well adapted to high-speed operation. Two units are shown here. The cover has been removed from one unit to show the herringbone gears.

tion possible in the space available, and consists of spur gears or idlers radially disposed about a central pinion and in turn meshing with a stationary internal gear. The so-called idlers must, of course, revolve on their own axis, but in addition must be free to climb around the internal gear. To that end they are mounted upon studs which are rigidly fastened to a spider mounted upon the slow-speed shaft.

There is also another type of non-planetary drive employing all of the planetary components, but the internal gear which is keyed to the slow-speed shaft, is allowed to revolve instead of the idler gear assembly as a whole. This type of drive gives a reduction intermediate between the non-planetary type mentioned and the planetary.

Planetary spur-gear reducers of the single-reduction type now available on the market are quite satisfactory for ratios between 4 and 8 to 1. When the 8 to 1 ratio is exceeded, they become rather large in diameter. Again, when the ratio is reduced below approximately 4 to 1, the speed at which the idler assembly revolves within the internal gear becomes excessive, causing needless agitation of the oil in the casing with consequent heating and power loss.

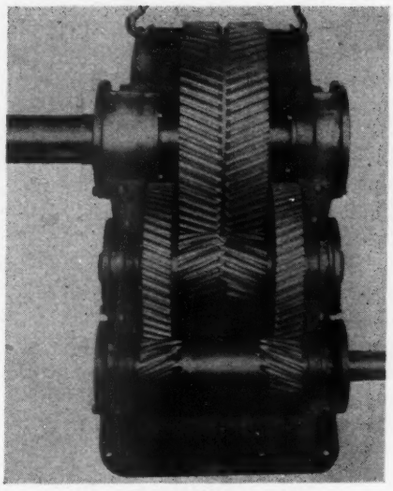


Fig. 5—This is a double-reduction type herringbone gear speed reducer.
The set of gears providing the first reduction is split and consists essentially of two sets of helical gears one of which is cut with a right-hand, and the other with a left-hand, helix.

The revolving internal-gear type (single reduction only) is best suited for ratios between 3 to 1 and approximately 7 to 1. The same limitations apply to this type as to the planetary type.

Referring again to the non-planetary type which does not employ the internal gear, this is admirably suited for smaller ratios, generally up to approximately 6 to 1 in the so-called single type. However, the single-reduction gear in this design is really a double-reduction gear. Very small ratios are possible, even a 1 to 1 ratio being obtainable, which is entirely impossible with any of the types previously mentioned.

It will be noticed, however, that the foregoing remarks have all been made about the single-reduction type. Where higher ratios are required it is, of course, necessary to "double up" the reduction; so, two drives are coupled in series in the same casing.

By making a simple calculation, it becomes obvious that ratios below about 12 to 1 are difficult to obtain in the double planetary design; hence, it is usual to couple a 4 to 1 and a 3 to 1 together to obtain this ratio. Thus, quite a perceptible gap exists between the maximum ratio of 8 to 1, obtainable in the single type, and the minimum of 12 to 1, obtainable in the double type.

The same remarks apply to the revolving internal-gear type with, of course, the limits changed somewhat; that is, the lower limit of the double type of this design is somewhere around 10 to 1.

None of these limitations apply to the non-internal, non-planetary drive although for the larger ratios the drive as a whole becomes extremely long.

It may be said, in general, that the one outstanding feature of all of these different types is that all unbalanced forces are neutralized, leaving nothing but a rotary motion. The greatest characteristic of these drives is that both the slow-speed and high-speed shafts are in a straight line which is an important advantage in a great number of instances. These different types are, when properly designed and constructed, very satisfactory, as shown by the very large number now in successful operation.

It may be pointed out, however, that the mounting of pulleys, sprockets or pinions upon either of the projecting shafts, without the provision of an outboard bearing seriously affects the alignment of the gears inside of the casing, with resulting injury to the gears and eventual failure of the unit.

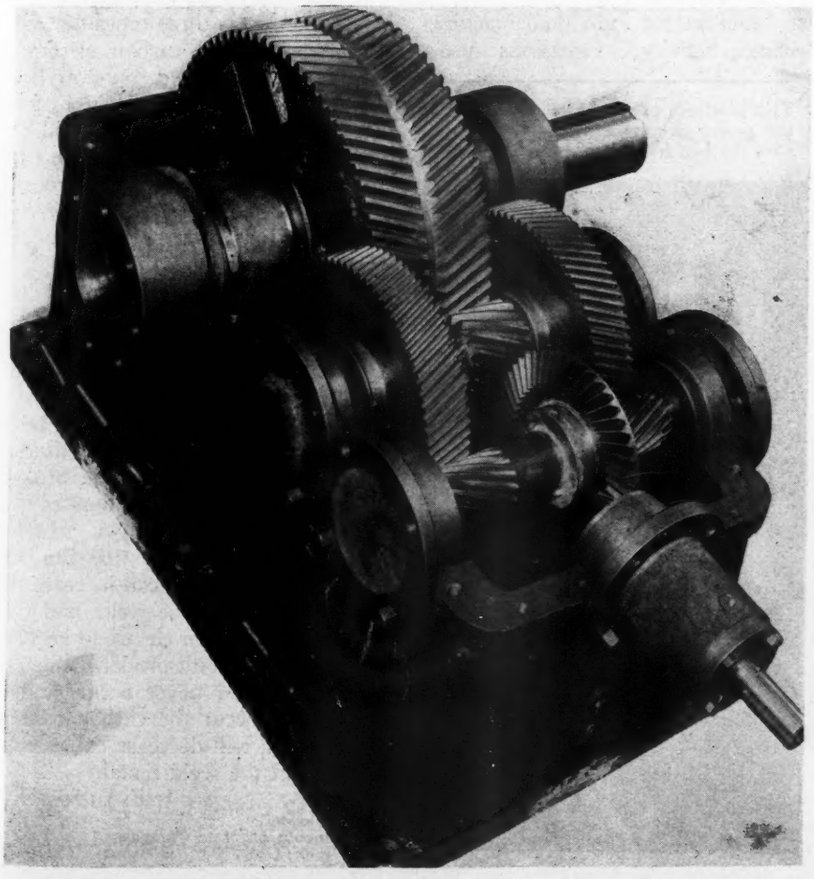


Fig. 6—Combination spiral bevel and double herringbone gear speed reducer.
This type of speed reducer may be used where a right-angle drive is necessary. The spiral bevel gears provide the first reduction in speed. The next reduction is obtained through the two sets of helical gears, and the third through the herringbone gears.

The statements made above regarding the lubrication of worm-gear reducers apply also to the spur-gear type.

Until a few years ago, the worm and spur-gear types of reduction units held undisputed sway. This popularity is being shared by the herringbone type of drive, which is highly efficient as well as silent in operation. It lends itself especially to the transmission of large amounts of power, although it is rapidly coming into its own for the intermediate and lower horsepowers in spite of its comparatively high cost.

The herringbone type of speed reducer does not possess the right-angle feature of a worm drive, nor "the shafts in line" feature of the spur-gear drive. Its high- and low-speed shafts are offset, although they are parallel with each other. Thus, it will be seen from Fig. 4, that a herringbone drive requires more floor space than any of the other types.

The single reduction type, consisting of one pinion and one gear—is commonly manufactured up to a ratio of about 7 or 8 to 1. In ratios over this, it is usual to obtain the required reduction in two steps. There are two distinct types of the double-reduction unit now available. One type consists of two sets of herringbone gears arranged in series. In the other type, Fig. 5, the first set of gears is split; that is, the first drive really consists of two sets of helical gears, one set being cut one hand, and the other being cut the opposite hand. They are mounted far enough apart to allow the insertion of the final drive pinion between the helical gears. This form of construction equalizes the loads on all bearings as well as making a more compact drive which is not the case with the first-mentioned type. These two types are commonly manufactured in ratios up to about 60 to 1. Greater ratios are more economically secured by the triple-reduction type.

A recent modification of the herringbone reducer which allows it to displace successfully the worm drive involves the use of a spiral bevel gear for the first reduction. A unit of this type is shown in Fig. 6. The spiral-bevel gear (the only true spiral gear) has been brought to a high state of perfection largely through its use in the automotive field; its use in connection with the herringbone unit makes this type of drive available where a right-angle drive is imperative.

The herringbone gear reducer is susceptible to the same influences as the other types of reduction units. Flexible couplings should be used as much as possible. Outboard bearings should be provided for any overhung loads. Lubrication recommendations should be carried out to the letter and, lastly, any unusual conditions should be brought immediately to the manufacturer's attention.

The foregoing discussion refers to the numerous standard drives now being manufactured by various companies, and should not be construed as applying to special types of drives which are manufactured for particular installations.

Substituting Suspended Platform for the Shop Ladder

IN ONE of the earlier factories built without its own power plant, the power and lighting circuits from the transformer on the street were brought through the wall near the ceiling where the meters, switches, and fuse boxes were mounted.

At first, there were but one power and two lighting circuits running from the board, but as the load increased, four power and eight lighting circuits were required.

The practice of under-fusing the lines resulted in an increasing number of delays to renew the fuses, as the loads on the individual machines became heavier. Occasions arose also, when meters had to be changed or tested and additional circuits had to be added. In order to reach the equipment installed at this location, it was necessary to interrupt the work at the bench. When meters had to be tested or new circuits installed, a temporary platform was constructed, but for ordinary repairs, such as renewing fuses, the shop ladder was used.

The inconvenience and the risk of using ladders at such times influenced the foreman to install the platform shown in the accompanying illustration. The cost was slightly more than that of the six boards and the white paint used to make it harmonize with the plant interior.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

This platform permits men to work on the power circuits without interfering with the bench work.

Comment on "The Selection of a Welding Process"

AN ABSTRACT of a paper "The Selection of a Welding Process" by L. E. Everett of the Nugent Steel Castings Co., Chicago, Ill., appeared on page 313 of the July issue of INDUSTRIAL ENGINEER, in which the application of three welding processes to his work was discussed.

It was stated in this article that Mr. Everett uses three types of welding processes—the carbon electrode, metallic electrode, and oxy-acetylene. There is no reason for the use of all three of these processes, for all of the work, in general, can be done with either the electric or the gas process.

There is one reason, and one reason only, for using welding in the work described, and that is to save money. With proper technique the electric process will do all the work that the other process will do and, in general, that fact is being fully recognized.

There is one statement made, however, which should be corrected: that is, that the carbon electrode process increases the carbon content in the weld. This is positively a mistake. There is only one way that the carbon electrode process can increase the carbon content in the weld, and that is to dip the carbon electrode into the molten metal. With proper manipulation this should never occur, and if it does not occur the carbon content in the metal will decrease rather than increase in the weld metal.

J. F. LINCOLN.
Vice President,
The Lincoln Electric Company,
Cleveland, Ohio.

Breaking the glass turns in an alarm. Fire protection equipment shown here includes: (1) Fire hose. (2) Pyrene carbon tetrachloride, 1-qt. size. (3) List of alarm stations. (4) Break-glass-front Autocall alarm station. (5) Self-closing waste can. (6) Section marker. (7) 2½-gal. Foamite extinguisher. (8) 5-gal. Foamite extinguisher.

Providing Fire Protection

for an industrial plant

By AL ANSELM
General Superintendent
Fansteel Products Co., Inc.
North Chicago, Ill.

INDUSTRIAL fire protection problems result from the hazards presented by the type of building, construction, the contents, or the processes employed. Modern buildings and many processes offer practically no fire hazard in themselves. The contents in practically all types of industrial works are burnable, sometimes highly inflammable, and cause a hazard even in the so-called fireproof building because a serious fire in the contents will damage the building.

Our plant, in contrast to many others, offers a triple hazard in that several of the buildings are old and of mill-type construction. The processes in several departments involve reductions under high temperatures or the use of highly inflammable materials, and the product, especially when packed, is highly inflammable. In addition to this, our plant is located in a comparatively small town, and even though there is a good local fire department, for a town of its size, this fire department would be handicapped in fighting a big fire in an industrial plant.

Our plant is engaged in the reduction of rare or special metals, such as tantalum, tungsten and molybdenum; in the case of tantalum very high temperatures are required for reduction, whereas reduction of the other two metals involves the use of large quantities of hydrogen gas. Tantalum is used in all Balkite radio and industrial chargers, as well as in the B battery eliminators. Pure tungsten is used for distributor points in automobile ignition systems, and molybdenum for various applications, including grid wire, in radio vacuum tubes.

The plant consists of 16 buildings containing about 120,000 sq.ft. of floor space. One of these buildings is four stories high, two buildings are three stories high, three buildings are two stories high, and ten buildings are single story. Only two of these, the office and building No. 3, are of modern, concrete fireproof construction; the others are of the pressed-steel, portable-building type, or of mill-type construction with brick walls. Some of the latter buildings are quite old.

With all of these hazardous conditions our only safe protection against

fire is to provide facilities to put out any fire before it has had an opportunity to get a real start. This is the basis of all of our protection at this plant. As a result, we have organized our fire protection activities along the following lines:

(1) An ample number of portable hand extinguishers are placed convenient to all serious hazards, and a smaller number in all other locations, even though less hazardous. These extinguishers are supplemented by three 40-gal. chemical carts and a wet and dry-pipe sprinkler system.

(2) A fire department recruited from the plant personnel whose training is supplemented with fire drills.

(3) Well-trained night watchmen who are organized into a fire department for night fire protection.

(4) An alarm system so arranged that a fire alarm may be turned in from practically any point in the plant and at the same time signal the local city fire department.

Perhaps the first comment a stranger would make on coming into some of our departments would be in regard to what might seem to be a surplus of portable extinguishers. In the departments where the greatest hazards are present a portable 2½-gal. or 5-gal. Foamite-Childs extinguisher filled with Foamite is placed on each floor at each column down the center of a fairly narrow building. The 2½-gal. extinguishers are hung from the columns and the 5-gal. extinguishers are set a few inches above the floor, alongside the column. This provides an extinguisher about every 15 ft. in a building approximately 220 ft. long.

In addition, two hand carts with 40-gal. tanks, also filled with Foamite, are placed in this same building—one on the first floor and the other on the second. These carts are moved to the most active floor in case production in some departments is reduced, but are never taken from this building. The special hazards in this building are due to the molten compound used for insulating coils and for sealing the Balkite trickle chargers.

Dry valve on dry-pipe sprinkler system.

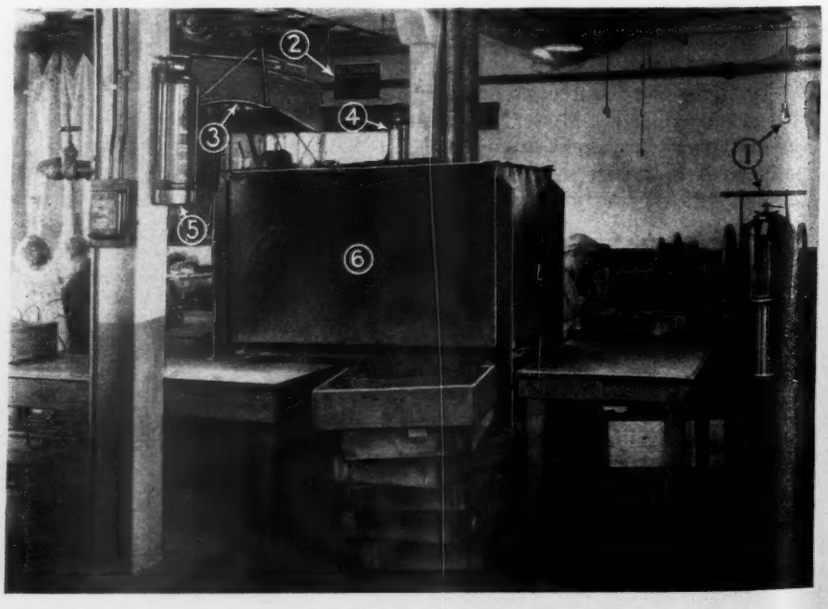
In buildings which are difficult to heat, such as the warehouse in this plant, dry-pipe Rockwood sprinklers are used. Air pressure in the sprinkler lines balances the water pressure against a diaphragm in this valve. When a sprinkler head opens the air pressure is released, whereupon the water breaks the diaphragm and fills the sprinkler lines. Two electric strip heaters are fastened to the water side of the pipe to keep it from freezing.

A red light burns continuously at all exits and also just above the three 40-gal. Foamite carts. These red lights are on a separate circuit leading directly from the main distribution switchboard on the incoming lines from the transformers. Because they are not connected into the local lighting cabinets they cannot be turned off accidentally. Also, they are not affected by fuse failures on the regular lighting circuits.

We selected Foamite protection here because of its smothering action on oil, pitch or wax fires. Altogether, this building contains 36 2½-gal. and 6 5-gal. Foamite extinguishers, 20 1-qt. Pyrene carbon tetrachloride, and 4 soda-acid extinguishers and the 2 40-gal. Foamite carts. In addition, the building is provided with a Rockwood sprinkler system, which is illustrated and described on this page.

Dry-pipe sprinklers are used in some of the buildings because of the danger of freezing during cold weather. As stated, some of these are old buildings and difficult to keep warm. Two electric strip heaters are fastened on the side of the pipe just below the valve for use in extremely cold weather.

Practically 90 per cent of the plant is provided with Rockwood sprinklers. However, one old building which is isolated from the others is not provided with sprinklers. Fyr-Fyter carbon tetrachloride extinguishers of 2-gal. capacity are placed in the warehouse and other locations using the dry-pipe sprinklers where the chemical in the extinguisher is exposed to low temperatures. Carbon tetrachloride does not freeze until about 40 deg. F. or more below zero, whereas some other chemical extinguishers



Fire protection equipment in one of the more hazardous locations.

This is one of the floors on which baking ovens and vats of molten compounds create a serious hazard in a mill-type building. A red light burns continuously above the 40-gal. Foamite cart (*1*) which is never taken from this floor. The "No Smoking" rule (*2*) is strictly enforced. Fire hose (*3*) is mounted on the column. A 2½-gal. Foamite extinguisher (*4*) and (*5*) is mounted on each column. Foamite is used in extinguishers because of the smothering action of the Fire-Foam on wax and oil fires.

that have water solutions will freeze at temperatures above zero.

Electrical fire hazards also require the use of carbon tetrachloride extinguishers because the chemical is a non-conductor and can be directed upon live circuits without any serious consequences. Therefore, a 1-qt. Pyrene carbon tetrachloride extinguisher is placed at each electric furnace, at the electric heaters for melting the insulating compound, and near other electrical hazards. In addition, a number of ½-gal. Fyr-Fyter carbon tetrachloride extinguishers are placed at other parts of the plant.

As stated, the two 40-gal. carts are not removed from this extra-hazardous building. Another 40-gal. cart is kept in the boiler room, which is centrally located, and is used by the fire department when reporting to any alarm.

Each fire extinguisher carries a tag showing when it was refilled last, and after an extinguisher is used it is placed on the floor instead of being hung back in position. However, the fire chief in his weekly inspection looks for empty or partially filled extinguishers by actually lifting and shaking each. All extinguishers are emptied and refilled once a year. All fire hose is tested once each year and defective hose replaced. Special gum-rubber-covered hose is used in departments where it is exposed to acid fumes.

For some time we were bothered by men using the carbon tetrachloride taken from an extinguisher for cleaning their hands or removing spots from their clothes. As a result, we frequently found a number of these extinguishers empty or partially empty, but still in position. This difficulty has been overcome by the addition of some red oil dye to the tetrachloride. Since then we have had no trouble from this source.

The plant fire department consists of eight men, including the chief, during the day shift, and a similar number of watchmen who also serve as firemen at night, under the direction of a chief watchman. The day fire department is composed of the yard foreman, who acts as chief, the steamfitter, the electrician, two men from the machine shop, and three others from various departments.

The first three of these are men who are thoroughly acquainted with every part of the plant because their work carries them into all departments. Also, the electrician is available to cut off the power on any line, if necessary. The other members of the force are selected from men who can leave their work without any serious interference or loss as soon as the alarm is sounded. Primarily, they must be men who can think clearly and are not easily excited.

Fire drills are held twice a month, for which the men receive $25 a year in semi-annual payments (January and July) as a reward for this extra work.

When an alarm is sounded these men report to the boiler room. They then take the 40-gal. Foamite cart, axes, and other equipment to the part of the plant where the alarm was turned in. The code number of the alarm indicates the location. The eight night watchmen are drilled similarly and report after every night alarm in the same way.

During the day when the plant is operating, a fire could gain but little headway before being discovered and attacked with an extinguisher, or an alarm sounded. Ordinarily, a fire at night has a much better opportunity to gain headway. We endeavor, however, to give a night fire as little chance as possible to grow by having frequent inspections made by the watchmen.

For example, in the most hazardous building, one watchman devotes his entire time to making two complete rounds per hour. His trips are begun on the hour and on the half-hour. In addition, one of the other watchmen, who also looks after another building, follows him up, beginning on the quarter after and ending at a quarter to, the hour; a third watchman begins his rounds in this building at a quarter to the hour and ends at the quarter after. As a result, every point in this building is inspected every 15 min. by one of three men.

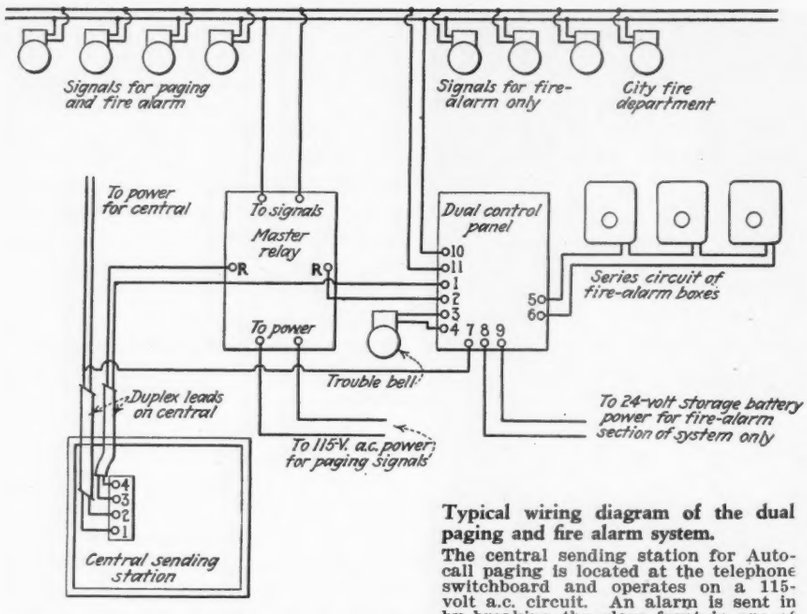
Of course, if a fire had a 15-min.

The alarm circuit requires a reliable source of power.

The storage battery, which is charged by a Balkite trickle charger, is used to sound the trouble bell through the dual control board so that even though all outside sources of power are cut off an alarm will sound. The members of the fire department who are in this building take with them one of the extinguishers shown here, when they respond to an alarm.

The company fire department in action.

When an alarm is sounded, the men seize a 2½-gal. extinguisher and report to the boiler room to get this 40-gal. Foamite cart. The hose cart is stationed in the small shed at the left where it is convenient to the hydrant.



Typical wiring diagram of the dual paging and fire alarm system.

The central sending station for Autocall paging is located at the telephone switchboard and operates on a 115-volt a.c. circuit. An alarm is sent in by breaking the glass front in one of the fire alarm boxes. The dual control panel cuts out any paging calls which might be sounding and turns in a fire alarm on the paging-signal system, the trouble bell, and the special "fire only" alarms, one of which is located at the city fire department. If the alternating current power should fail the trouble bell and the "fire only" signals, which are on the storage battery circuit, would still be sounded.

start it would probably be beyond control. However, it is not very likely that a fire could start without there being some indication more than 15 min. before flames burst out. Also, if one watchman should fail to detect an incipient fire, one of the other two watchmen would be likely to discover it. Every other building in the plant is covered by watchmen, but not so frequently as this.

The watchmen carry Hardinge portable clocks which are punched by keys located at each of the 30 watch stations. Each of these keys carries a different letter, symbol, or number which is printed on a tape in the clock, indicating the station and the time. Arranging the numbers in sequence, or having the letters spell a word indicates at once whether the watchman has made his rounds in the proper order. An extra long space between letters or symbols indicates that too long a time has elapsed between visits to stations.

The watch stations are located so that the watchman must pass the full length of every room or floor to get from the station in one end to the station in the other. In addition, stations are placed at some of the more hazardous locations so that the watchman must at least stop there.

This entire protective system is tied in with the coded alarm system which may be turned in from any one of the 26 fire alarm stations about the plant. These stations are placed where they are easy to find, particularly by the night watchmen, but they are in no way connected to the watch stations.

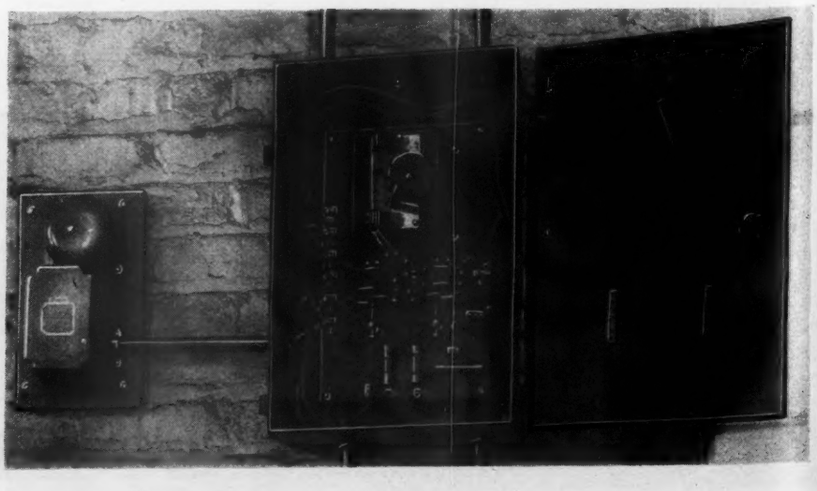
Coded alarm signals are transmitted through an Autocall paging system which is used to call or page from the telephone switchboard, by means of a coded number, any individual or executive when he is out in the plant or away from his regular location. It is possible by connecting devices approved by the Underwriters' Laboratory to use this circuit for the delivery of coded fire alarms.

Alarms are turned in at any of these 26 stations by breaking the glass in the Autocall fire alarm box, as is shown in the illustration on page 405. These fire alarm boxes are wired in series on a circuit of No. 10 rubber-covered copper wire in conduit. The type of circuit used is shown in the accompanying drawing.

When put in operation, these boxes transmit, through the dual control board, a distinctive coded alarm for fire throughout the plant on the regular Autocall paging circuit. Each alarm station has its number and the members of the fire department are supposed to know the location of the box corresponding to each number. However, a list of these stations is placed at each box and in the boiler room where all firemen report so that they can check the location, if necessary.

With this installation both the fire alarm box circuit and the fire alarm signal or bell circuit are constantly under automatic supervision so that there is an immediate indication when anything goes wrong. This is given by means of a bell located adjacent to the dual control board and shown in the illustration on this page. The circuit is normally closed; therefore if impaired for any reason the trouble bell will ring continuously. Without automatic supervision such as this the system might get out of order and fail to operate in an emergency.

The dual control board mentioned above is supplied with binding posts for a "fire only" circuit. From this point on the dual control board is installed a circuit of bells which will operate only from a fire alarm box. This means that in addition to the fire alarm sounding throughout the plant on the paging circuits there are a number of signals sounding the same alarm, which are silent at all times



The heart of the fire alarm system.

By means of this dual control panel the Autocall paging system is connected into the fire alarm box circuits and the "fire only" circuits so that the paging circuit is cut out when an alarm is sounded. The trouble bell at the left signals all fire alarms and also any interruptions or trouble on the fire alarm box or "fire only" lines.

except on the operation of a fire-alarm box.

These special alarm bells, which consist of large gongs, are not used in the paging circuit but are located at various places around the plant yard so that anyone working outside will hear them. In addition, a gong in the power house gives the signal to the engineer who repeats it on the whistle.

By means of a connection between the "fire only" terminals of this dual control board and the city of North Chicago's fire alarm circuit, all coded alarms sounded within the plant are transmitted simultaneously into the city fire department upon the operation of any fire alarm box within the plant. On a recent test of this equipment by state fire officials, the city fire department which is located ½ mile away was on the ground in less than 2 min.

Another feature of this installation is the use of what is known as an Autocall selective relay. In the past many such connections between local fire alarm and city fire alarm circuits have been made, but in recent years the privilege of making such connections has been almost universally denied because of the many false alarms turned into the city fire department through such connections.

This selective relay, which consists of an air-dashpot element, is installed between the dual control board and the city fire alarm circuit on the "fire only" circuit of the dual control board and is so arranged that a false alarm cannot be sent into the city fire department, regardless of what takes place on the local circuit. In this case the local fire circuit can be cut without transmitting impulses to the city fire circuit.

The fire alarm boxes are so arranged that upon the arrival of the company firemen in response to an alarm it is possible, by the use of a special key, for the chief to manually signal from any box codes that he might use for indicating that the fire is out, or to call additional assistance, or for any other use.

The plan of using a common circuit for paging purposes from the telephone switchboard and for the delivery of coded fire alarms naturally brings up the question of what happens in the event that this common circuit is actually in use for paging purposes when one of the fire alarm boxes is put in operation.

This contingency is taken care of because the dual control board is equipped with a time-element device which cuts out the Autocall paging device located at the telephone switchboard the instant a fire alarm box is placed in operation. This cut-out is complete and remains until four standard rounds of the fire alarm have been sounded, when the time-element device again automatically cuts in the paging device located at the telephone switchboard.

A further complication would seem to arise in the use of a common circuit in case the firemen were not able to distinguish between a coded paging call and a coded fire call. This is cared for by preceding all coded fire calls by ten rapid strokes of the signal bells, which are then followed by a slower code indicating the fire box in operation. These ten rapid strokes, followed by the slower code, are sounded four times when a fire alarm box is put in operation.

In the use of this circuit for paging purposes the paging codes are very slow in operation and no paging code, irrespective of how many men are subject to paging, ever transmits more than seven continuous impulses to the paging circuit. Therefore, ten rapid strokes on this circuit instantly spells fire to the fire organization and the following slower code designates the location of the fire.

The fire alarm box circuit and the "fire only" signal circuit are operated from a 24-volt storage battery. The Autocall paging equipment is operated from the 115-volt lighting circuit. Should the alternating-current lighting circuit power fail, the fire alarm would sound on the "fire only" circuit and through the dual control board to the city fire circuit. The 12-cell storage battery we use to supply power to the fire circuit is kept charged by means of a Balkite-type trickle charger which is constantly in the circuit.

With all our hazards it seemed at first as though adequate protection and safeguarding against fire were impossible. However, by providing an ample number of extinguishers and training both day and night men to operate them, and also by installing a signal system to sound the alarm and call the men to the fire as soon as possible, we have decreased the hazard sufficiently to obtain additional insurance at a better rate. In conclusion, I might add that real fire protection is fire prevention; in other words, "Don't give fire a chance."

Recommended Practices in Installing and Testing Grounds

FROM an analysis of the information obtained by the National Electric Light Association, and reported in publication No. 267-63, no doubt is left of the opinion held by the majority of engineers of the value of inspection work in transformers and their grounds, not only from the viewpoint of continuity of service, but its economic value as well.

It is suggested that in those sections where the ground conditions are not good, enough tests be made to decide whether ground testing and soil treatment are desirable or not.

In general, the ground rods should be located as near as possible to the apparatus to be protected, but where a dry, high-resistance soil is encountered nearby and a better location can be obtained, 100, 200 or even 300 ft. away, it should be utilized in preference to the less favorable location close at hand. In this case at least one pipe should be driven as close as possible to the apparatus to be protected regardless of soil conditions, and as many more pipes driven farther away as are necessary to bring the total ground resistance down to the required value. This value should not be greater than 15 ohms.

In no case should less than two pipes be driven. It will not be found advantageous to drive more than six or eight pipes in any one group. When this number does not bring the ground resistance to less than 15 ohms, another group should then be driven not closer than 15 or 20 ft. to the first group. No individual pipes should be located closer together than 6 ft., except where it is impossible to obtain this clearance.

In places where a pipe projecting above the ground would be objectionable, it should be cut off 6 in. below the ground level and the soldered joint painted with tar. Avoid making any joints underground wherever possible, and none are allowable in the wire unless it is absolutely impossible to prevent them—then they should be coated with tar.

All ground pipes should be tested for resistance at the time of instal-

lation and periodically, as determined by future tests.

For this purpose a transformer (used to supply an ungrounded source of energy), two resistance units of 20 ohms each and voltmeter will be used, the connections of which are shown in the accompanying illustrations.

As it is necessary to drive two or more pipes, it is necessary to secure the individual resistance, and then since the pipes are connected in multiple, the combined resistance of the pipes will be the reciprocal of the sum of the reciprocals. The algebraic solution for individual resistance will be fairly accurate only when all the pipes are identical, equally spaced not less than 6 ft. apart, and soil conditions are uniform for all pipes.

The apparatus to be used in testing will consist of one ammeter, 5 to 10 amp. range; one ammeter, 1 to 2 amp. range; one voltmeter, 150-volt range; one 15-ohm resistance with short-circuiting switch; two 6-ft. ground stakes, and the necessary test leads.

Readings of voltage and current are to be taken in accordance with the methods to be outlined and in the order given. If measurements indicate that the resistance of the ground under test is greater than 250 ohms, it will be necessary to reduce this value by treating the soil in the following manner:

Dig a basin approximately 2 ft. in radius and 1 ft. deep, surrounding the ground stake. Place a minimum of 60 lb. of coarse rock salt in this basin and flood the hole with water until the surrounding earth is well saturated. Back-fill the basin with the soil previously removed and add water until the back-fill is also well saturated.

A second resistance test should be made the following day.

Fig. 1 shows the method to be used in locations where the secondary neutral is solidly grounded to the water system. When testing grounds by this method, a 15-ohm resistance which is provided with a short-circuiting switch and an ammeter are connected in series with the live side of the secondary main and the ground to be tested. A voltmeter is connected between the point at which the resistance and the ammeter are joined and the secondary neutral. In cases where the current is too small to be read on an ammeter, a voltmeter, used as a milliammeter, may be used in place of the ammeter. Inasmuch as it is usually not necessary to read voltage and current simultaneously, the same voltmeter may be used for both readings in this case.

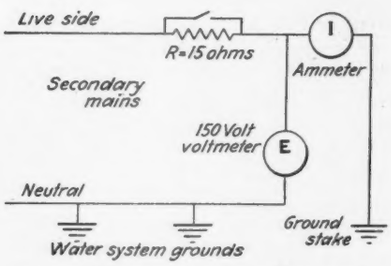


Fig. 1—Diagram of connection used to test grounds where secondary neutral is solidly grounded to water system.

The following steps should be followed when testing by this method:

(1) Start the test with the short-circuiting switch open, using the 10-amp. scale of the 5 to 10-amp. ammeter. If the reading is below 5 amp.,

(2) Connect to the 5-amp. scale. If the reading is less than 2 amp.,

(3) Close the short-circuiting switch. If the reading is less than 2 amp.,

(4) Substitute the 1 to 2 amp. ammeter using the 2-amp. scale. If the reading is less than 1 amp.,

(5) Connect to the 1-amp. scale. If the reading is less than 0.2 amp.,

(6) Substitute the voltmeter for the ammeter.

It is advisable to choose a step which will give somewhere near half-scale deflection on both the voltmeter and the ammeter. When such a combination is found, take readings of the current (I) and voltage (E). If the voltage is fluctuating, these readings should be taken simultaneously, or their averages estimated. When an ammeter is used (steps 1-5), the resistance (R_g) of the ground may be calculated by dividing the voltage (E) by the indicated current (I), or $R_g = E \div I$. When the voltmeter is used as a milliammeter (step 6), the resistance (R_g) of the ground may be calculated from the following equation: $R_g = R_v\ (E_1 - E_2) \div E_2$, where R_v = resistance of voltmeter range used in measuring E_2. E_1 = same as E when ammeter is used. E_2 = reading when voltmeter is used as milliammeter.

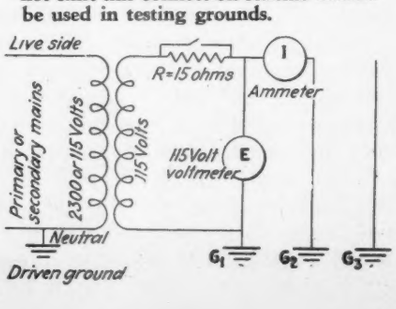


Fig. 2—When a known ground does not exist this connection scheme should be used in testing grounds.

At a location where a poor ground or none at all exists with which to complete the test circuit, drive two ground stakes G_1 and G_2, as indicated in Fig. 2, 4 ft. into the ground and at least 6 ft. but preferably 15 ft. apart, and use the method shown in Fig. 2 for testing. In this case, it is necessary that the source of supply be ungrounded; this may be obtained by using a 115/115-volt transformer in the existing secondary mains, or a 2,300/115-volt transformer in primary wires.

Test as described above between grounds G_1-G_2, G_1-G_3, and G_2-G_3, to obtain the resistance $R_1 + R_2$, $R_1 + R_3$, and $R_2 + R_3$, respectively. The resistance of the individual grounds will be:

$$R_1 = [(R_1 + R_2) + (R_1 + R_3) - (R_2 + R_3)] \div 2$$
$$R_2 = [(R_1 + R_2) + (R_2 + R_3) - (R_1 + R_3)] \div 2$$
$$R_3 = [(R_1 + R_3) + (R_2 + R_3 - (R_1 + R_2)] \div 2$$

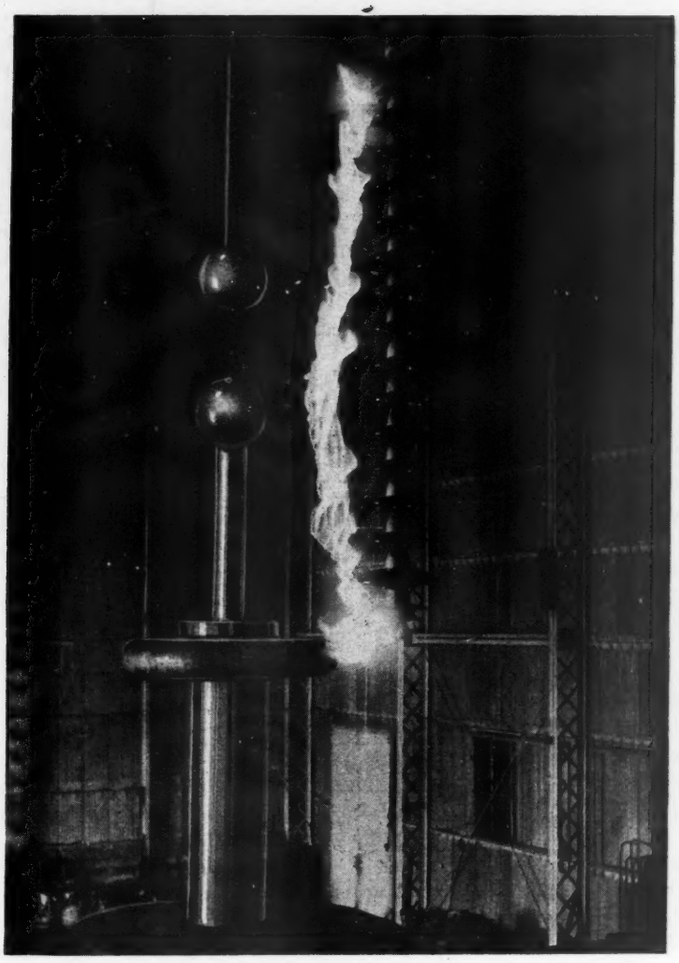
Emergency Use of Oversized Cable Clamp

THE wire cable on a hoist is only as strong as the clamp which secures the ends. The proper size of clamp, however, is designed to withstand the breaking load of the cable, when properly secured.

In several instances where accidents have occurred due to failure of the hoisting cable, examination has shown that the clamps were improperly secured, or that the clamp was of a larger size than the cable used on the hoist.

In practice, clamps are frequently found to be loose after putting a load on the hoist cable. To remedy this it is an excellent precaution to tighten the clamp with the cable under load, when the strands are taut and the cable diameter is slightly reduced. When it is necessary to use an oversized cable clamp it is advisable to put three thicknesses of cable under the clamp by doubling back the free end. It has been found that this is better than filling out the space with smooth iron or steel. It is well even with this arrangement to put the cable under strain before the bolts are finally tightened. G. A. LUERS.

Washington, D. C.



A flash 20 ft. long at 850,000 volts shows the general characteristics of the arc.

The central core is surrounded by a gas envelope which assumes different shapes and forms.

Considerations that influence design of

Arc-Rupturing Devices

By H. D. JAMES
Consulting Control Engineer, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

WHEN a contact is broken in any circuit an arc is formed, so today arc rupturing is an important function of control and it is one of the most interesting and fascinating problems in the whole range of engineering. It has been studied from many angles and a great deal of data collected, yet engineers are far from having an exact understanding of this subject, and thousands of dollars are being spent every year in developing theories and checking them by tests in order to arrive at better solutions of the different problems.

Arc rupturing is becoming of increasing importance as the power supply increases. This is most evident in the circuit breakers which are sectionalizing our great interconnected power systems. In motor control we are passing from the small isolated transformers or individual generators to systems which are capable of delivering a large amount of electrical energy through a short circuit or ground. Control apparatus which was adequate 10 years ago must be carefully considered today to determine if it is still safe to use or if additional protection against short circuit or ground should be provided.

In thinking of arc rupturing our mind at once turns to circuit breakers, switches, fuses, magnet contactors, cam controllers, drum controllers and even the face-plate type of control. Each of these devices has its particular problem and limitations. To better understand this problem, let us consider a description of the electric arc.

When two current-carrying contacts are separated the current continues to flow by establishing an arc between the two contact surfaces. This arc is an electric conductor and consists of a stream of charged particles in the form of a tube or core surrounded by luminous gas. This gas protects the core or current-carrying part from radiation and helps it to maintain a high temperature. The gas in direct contact with the core is, of course, very hot, but as we recede from the core this gas covering gets cooler and cooler until it is no

Minimum Arcing Distances Between Contacts and Grounded Enclosures in Ventilated Cabinets

Horse-Power Rating	Distance from Contacts in Direction of Blowout		Vertical Distance Above Contacts Without Blowout				Horizontal Distance from Contacts and Distance Below Contacts	
	D.C.	A.C.	D.C.		A.C.		D.C.	A.C.
	300 Volts	600 Volts	300 Volts	600 Volts	300 Volts	600 Volts	300 Volts	600 Volts
5	1¾	3	4	Bar	1¾	3	¾	1½
10	2	4	5	Bar	2	4	¾	1½
50	3	5	6	Bar	3	5	1	2
100	4	*	*	Bar	4	*	2	3
Above 100	*	*	*	*	*	*	*	*

*Indicates barriers. All distances to be measured n inches from contact tips or arc horns. Where the walls of the enclosure are not protected by barriers or a lining of non-combustible insulating material, the arc-rupturing parts of the controller shall have the above air spaces between them and the walls of the enclosure, unless a test on any specific device demonstrates that a smaller space is safe for that particular device.

longer luminous. In observing an arc often we see the flash travel a considerable distance, but a large portion of this flash is low-temperature gas. This fact can be shown readily by attaching a piece of tissue paper to a stick and holding it in the outer part of the arc. I have seen persons who were willing to put their hands in the path of this luminous gas to demonstrate how cool it was, but I do not recommend this practice.

The arc continues to carry current as long as the central portion remains hot enough to maintain the flow of charged particles. The arc is ruptured by stretching it and cooling it. It is, therefore, important to provide a reasonable separation of the contact members in order to insure the rupturing of the arc. The longer the arc continues, the more charged particles will accumulate, and, therefore, the more difficult it is to rupture the arc. This is particularly true where the arc is inclosed between barriers. The more rapid the separation of contacts, the more efficient the rupturing device.

Atmospheric pressure has a great deal to do with arc rupturing; sometimes artificial pressure has been resorted to, but usually the arc is ruptured under natural atmospheric conditions. Everyone is familiar with the fact that the pressure decreases as the altitude increases. Some of you may have experienced difficulty in boiling potatoes at a high altitude. Owing to the low atmospheric pressure, water boils at so low a temperature that it does not develop enough heat to cook the potatoes properly. The electric arc is also influenced by this decreased pressure, as it is much easier for the charged particles to maintain the flow of current between the arcing surfaces, and much longer arcs will result. A very good illustration of the effect of altitude on control equipment was experienced by a copper company in South America at 11,000-ft. elevation. Apparatus designed for ordinary elevations was not successful and had to be changed in order to make the arc-rupturing devices effective at this high elevation.

All control apparatus should either be isolated or enclosed in order to protect persons from injury by the arc or by accidental contact with live parts. These enclosures have an effect upon the design of the arc-rupturing parts. Every time an arc is ruptured, conducting gases are developed. If this arc rupturing is repeated rapidly, as sometimes occurs in "inching service," the enclosure becomes filled with charged particles and a flashover may occur outside of the arc barriers between opposite sides of the line. Wherever possible the enclosing case should be ventilated. If a tight enclosure is necessary the arcing duty should be reduced to a minimum.

Several years ago the control manufacturers co-operated with the Underwriters' Laboratories in establishing the minimum arcing distances between contacts and grounded enclosures in ventilated cabinets. These distances are given in the accompanying table. Where it is necessary to use shorter distances, barriers should be provided or the inside of the enclosure should be lined with insulating material. As previously pointed out, the gases surrounding the arc on the outer edge are cool, so that often a thin sheet of asbestos attached to the inside of the enclosure will afford satisfactory protection. Experience is necessary, however, to know what degree of protection is required in each particular design, but if there is any doubt it is better to provide too much protection than risk burning up the controller.

Arcing contacts are usually separated from those of opposite potential and also from grounded parts by barriers. A great deal of study and experiment is often necessary to get the best results from these barriers. It is surprising how the charged particles will penetrate very small cracks. At first no trouble will result, but the gradual deterioration of the insulation surface due to these charged particles will ultimately cause a breakdown which may so badly burn the switch that it is hard to tell where the trouble originated.

It is difficult to find a material for arc barriers which has all of the desired characteristics. It must, of course, be fireproof. This means that it will be more or less hygroscopic and may absorb moisture when not heated by the arc. This moisture reduces its insulation properties and is particularly objectionable from the standpoint of surface creepage. Many otherwise good materials when subjected to arcing, deposit a conducting slag on their surface. This slag comes from the binder used for building up the material which is boiled out by the high temperature of the arc and combines with copper or copper oxide from the contacts. Generally, it is a better conductor when hot. When this slag forms it should be scraped off from time to time. Some materials close to the contacts burn away very quickly and must be frequently renewed. The research departments of large companies are continually working on this problem and are improving the materials available for arc barriers.

Severe conditions may not exist in a particular design so that an ordinary piece of insulation will serve the purpose such as asbestos, slate or even wood fiber.

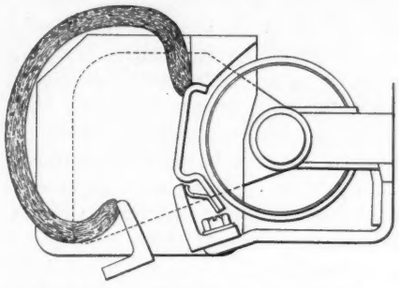
The insulation of the live parts of a magnet contactor or other control devices presents an interesting problem. If the insulation surface is remote from the arc, and the atmosphere reasonably clean, there are many materials that are satisfactory for insulation purposes and only short spacings are necessary. If these surfaces are cleaned from time to time and given a coat of insulating varnish, no trouble should result.

Where the insulation surface is in the neighborhood of the arc a more difficult problem arises. The charged particles in the arc come in contact with the insulation surface and may cause an incipient discharge across this surface. At first this will not be noticed, but in time it may cause sufficient deterioration to result in a flashover. The writer has had many experiences of this kind. One particular case is recalled where a standard piece of control apparatus proved very satisfactory when used with a 7½-hp. motor, but this same controller when applied to a 10-hp. motor on the same service would flash over after approximately 6 mo. use. The controller was restored to its normal condition and was used another 6 mo. This process was repeated several times until we became thoroughly convinced that this particular design was not good for a 10-hp. motor on this service. We often explain trouble with electrical equipment by attributing it to some accidental condition, but if we find that the accident repeats itself several times we should be satisfied that an accidental condition is not the correct interpretation of the trouble.

Another insulation difficulty may be caused by metal fumes being distilled from the material in contact with the arc and deposited on the insulation surface. These fumes should be distinguished from the small metal particles which are separated from the surface by the arc. If high temperatures are experienced in an arc box, care should be taken to use metal which does not give off fumes at relatively low temperatures.

No piece of electrical apparatus should be considered as indestructible. Most maintenance men examine contacts and renew them when necessary, but it is also very desirable to clean the insulation surfaces from time to time and give them a coat of insulating varnish, particularly the surfaces that are in the neighborhood of arcing contacts. Care must be taken in selecting a good grade of varnish and also to avoid injuring the insulation when cleaning it. If in doubt on these two points, you should consult the manufacturer of the apparatus as he knows the composition of the insulation used and can recommend the best method of cleaning and the best varnish to use. The frequency of such overhauling will depend entirely on the service. Nearly all large street-railway companies give their electrical equipment a thorough overhauling at stated intervals. In one large city, I saw control equipment which has been in service for 25 yr. and is still being maintained in first-class condition. Intelligent care will make a wonderful decrease in the depreciation of electrical equipment.

There are two common methods used for rupturing arcs. One is the magnetic blowout and the other, the oil-immersed switch. The latter is not used to any extent for low-voltage control and is limited to alternating-current equipment. From time to time tests have been made on the effect of quenching a direct-current arc under oil, but so far these tests have shown that oil-immersed contacts are not very efficient for opening direct-current circuits. Alternating-current circuits are very effectually opened under oil; the arc is quenched by the oil when the current passes through its zero value. Large amounts of power have been opened in this way with relatively short separation of contacts. The greater the pressure of oil surrounding the arc, the more easily is the arc extinguished.



This shows the effect of a magnetic field on an electric arc.

The arc conductor is extended out in the form of a loop, at a distance considerably greater than that between the two contacts.

The magnetic blowout is used extensively for both industrial and railway control. The arc which is essentially a flexible conductor is moved by a magnetic field in the same direction as the conductor on the armature of a motor. This causes the arc conductor to form a loop extending out from the two contacts, as shown in the illustration on this page, so that its length can be made very much longer than the distance between contacts. The same results could be obtained by separating the contacts, but this would introduce practical difficulties in the design of a magnet contactor. This action of the arc in the magnetic field may be perfectly obvious for direct current, but some of you may wonder what happens with alternating current. The blowout magnet is in series with the arc so that the magnetic field reverses when the current in the arc reverses. This causes the arc to move continuously in one direction, but it is evident that the lag in the magnetic circuit of the blowout coil should be reduced to a minimum, otherwise its effective action is very much reduced. These iron circuits are usually laminated to improve their efficiency. Smaller contactors use solid iron which is slotted to obtain the same results.

In addition to stretching the arc, barriers are often interposed in the path of the arc to make it form several loops which increase its length and at the same time cools the arc by contact with these barriers. Cooling effects are also obtained by forcing the arc through a narrow slot or slots. If the arc is restricted in any way it tends to build up a pressure proportional to the energy being delivered to the arc. This pressure forces the charged particles out through any available opening so that care must be exercised to prevent this charged gas from getting to parts of the switch where it will cause an insulation breakdown. Skill in designing the arc box will eliminate this trouble when the energy of the arc is within the capacity of the switch.

The successful rupturing of the arc depends not only on the voltage of the circuit and the current ruptured, but also on the energy stored in the circuit which is discharged through the arc. Induction stores energy in the circuit in the same way that mechanical energy is stored in the flywheel. We are all familiar with the additional work that is required to stop a motor driving a flywheel on a punch press over that required to stop the same motor operating a plunger pump. In the same way, more difficulty is experienced in opening an inductive circuit than one having only resistance as a load, as may be noted by comparing the flashes in the pair of illustrations on page 414. This point may be proved by using a water rheostat for loading a d.c. generator and then adding a large series motor in the circuit and adjusting the rheostat to give the same current. If an oscillograph is used to measure the voltage across the contacts when the circuit is opened, it will be found that the inductive "kick" has raised this voltage from 40 to 60 per cent above the normal line voltage. This increase in voltage depends on the

amount of induction and resistance in the circuit. The same effect occurs in a.c. circuits and is expressed in the terms of the power factor of the circuit; for instance, it is more difficult to open a given circuit with a 50-per cent power factor than with 80-per cent power factor.

The amount of current that will flow if a short circuit or ground occurs depends upon the amount of power connected to the circuit and upon the impedance of the circuit. If the circuit is fed by a small transformer, the increase in current will cause the voltage to drop and limit the current, as the amount of current = voltage ÷ inpedance. This impedance is made up of both resistance and inductance. Most feeder circuits have sufficient impedance to limit the current to the arc-rupturing capacity of the control. A number of actual tests have shown that the current obtained on short circuit is often less than the calculated amount due to factors which were not considered when the calculations were made. Induction places a direct limitation on the current in alternating-current circuits and retards the increase of current in a direct-current circuit. Quick-acting circuit breakers can be adjusted to open a d.c. circuit before the short-circuit current has reached its maximum value. Usually the feeder circuits to d.c. motors have sufficient resistance to materially limit the short-circuit current and small controllers are protected from short-circuit by fuses which have a high rupturing capacity.

The performance of the arc is different for a.c. and d.c. circuits, and for different voltages. The a.c. arc is frequently broken when the current is near its zero value so in testing it may be necessary to open an a.c. circuit a number of times before the current is ruptured at its maximum value. Alternating currents are generally easier to rupture than direct currents.

The performance of d.c. arcs on 220, 230, 600 and 3,000 volts are very different. The 600-volt condition seems to be the most difficult. If the 3,000-volt blowout structure is liberally designed so as to properly stretch the arc, very little burning takes place as the current values are small. A recent inspection of some control switches which had been in use on a 3,000-volt locomotive, showed that the burning was very small, even after they had been in service 4 or 5 years. Alternating circuits of 550 volts seem to give the most trouble. The 440-volt circuit appears to be much easier to open than the 550-volt circuit. This deduction may be based on insufficient data but the writer's own experience indicates that the difference in performance between these voltages is quite marked.

Air-break contactors have been built for 6,600 volts a.c., but ordinarily are furnished for 2,200-volt circuits. The motors using these contactors are for hoist duty and may be from 500 to 1,000 hp. in capacity. This service requires frequent operation.

The flash and the noise of the arc when it is ruptured are probably more like artillery practice than ordinary tests in engineering. Even engineers accustomed to this work find it exciting. Perhaps I can describe the sensation of the average person at such a test.

A group of engineers stand at safe distances around the contactor, preferably towards the front. Each is provided with a colored glass to hold in front of his eyes to protect them from the light of the arc which will also cause the observer's face to become "sunburned." The circuits are carefully checked and the total current in amperes is calculated approximately. The oscillograph, however, will give the correct value. The voltage of the machine is then checked and all is ready for the arc-rupturing test. The circuit may be closed on the contactor or the contactor may be first closed and then the circuit completed through a circuit breaker. The oscillograph operator must have all of his adjustments ready to obtain the instantaneous record.

The oscillograph may be connected so that it starts to take its record when the circuit to the operating coil of the magnetic contactor is opened. One of the testers must stand by the circuit breaker to open it in case the contactor fails.

All of this preparation and the interchange of advice between the different testers adds to the tensity of the situation. The observer usually tightens his muscles and braces himself when the signal is given to complete the test. The trained observer knows what to look for and usually concentrates his attention on some particular detail of the contactor but the novice sees only a great flash and a sharp report, followed by a relaxation of his muscles and a sense of satisfaction that it is over. If the contactor fails to open the circuit, the arc holds on with a noise like a person tearing a cloth. A clean break goes out with a single explosive pop.

Sometimes the arc is ruptured and then reignites several times before it is finally broken. This performance causes a pulsating noise and an experienced observer can usually tell how many times the arc has reignited and can also judge the efficiency of the arc-rupturing performance by the sound and appearance of the flash without looking at the oscillogram of the test.

A considerable number of tests in succession during the day gives the inexperienced person the sensation of exhaustion, because of the work his muscles are required to do unconsciously every time a test is made.

Comparative arc-rupturing tests on a magnetic contactor opening an 825-amp., 500-volt d.c. circuit.

The ease with which the non-inductive circuit at right can be opened as compared to the inductive circuit at left is indicated by the arc.

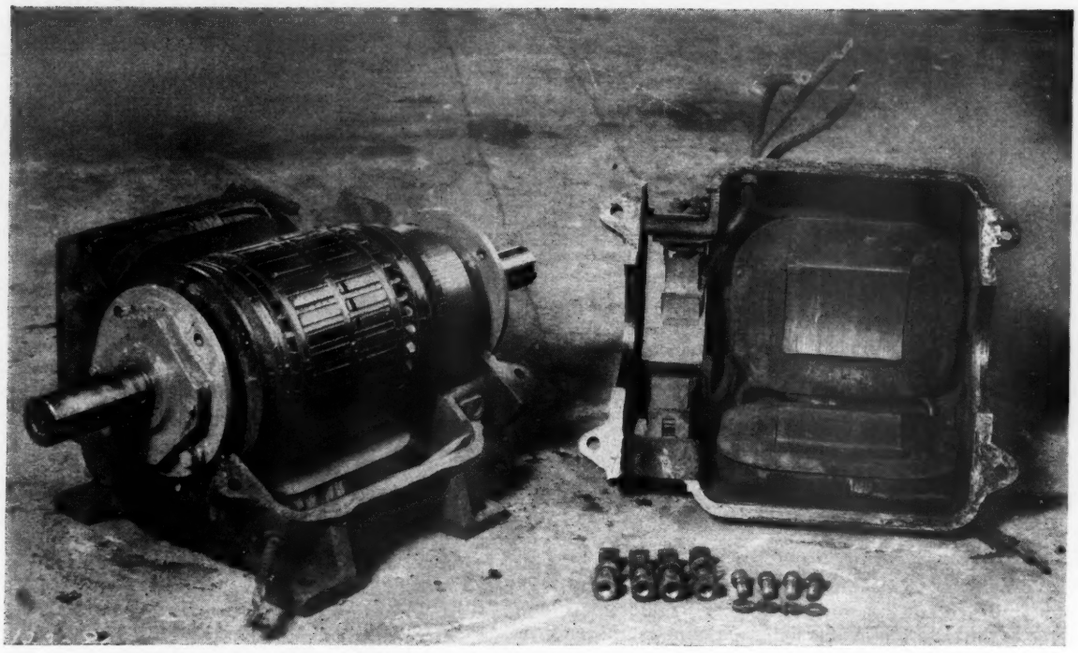


Fig. 1—One of the crane motors rebuilt for ball bearings. Bearing housings that could be attached to the frame by machining were designed for each size of motor.

Details of a simple

Equipment Record System

used in a large steel foundry

By JAMES THOMSON

Chief Engineer,
Hubbard Steel Foundry Company,
East Chicago, Ind.

IN the maintenance field, comparatively few plants present more serious or diverse problems than the large steel foundry. This does not refer to the size of the jobs nor to the amount of labor involved in performing the work, but to the variety of problems and the need for keeping equipment in as nearly 100 per cent working condition as possible. Because of its 24-hr. operation, the large steel foundry will compare favorably with the steel mill in regard to the need for eternal vigilance to keep the equipment ready for service.

The time when equipment is not at work and available for repairs is short, usually on Sundays only; hence it is very important that everything be done to reduce the necessity for repair to the minimum. This is a matter calling for close observation and study by all who are responsible for the operation of equipment.

In the earlier days of the steel foundry industry, very few companies had any engineering department. Equipment was purchased and installed and the plants run pretty much by the rule-of-thumb method. This naturally lead to rather hit-and-miss methods of maintenance. No adequate records of equipment and its maintenance were kept, and little or no attention was paid to proper design and standardization of equipment for the industry, except in the few cases where those in authority had the foresight to employ engineers from the start. To a large extent, the idea existed that operating methods used in and equipment built for the iron foundry would be suitable for the steel foundry.

In later years some of the companies have seen the value of the foundry engineer who devotes much of his time towards the solution of operating problems, particularly those involved in assuring continuous service. A number of these concerns have established their own engineering departments; others depend upon consulting engineering organizations for this work. Much credit is due to the engineers who have been through the pioneering days of the industry and have helped in the development of plants and equipment suitable for the special needs of this industry. A good deal of the present equipment has been developed as a result of the ideas or suggestions of these engineers, or from their insistence on designs suitable to the needs of the industry. In many cases the foundry engineer has had to practically rebuild existing equipment or to design his own equipment as there was nothing on the market to fit the job. In fact, this is how the manufacture of some of the equipment now available originated. The collaboration of the foundry engineer and equipment manufacturer has had much to do with the development of better and more efficient equipment.

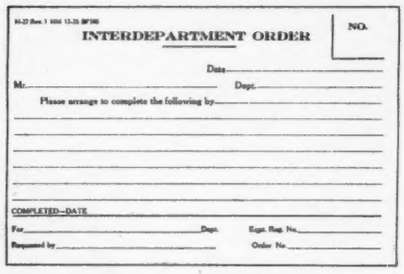
One of the developments which we

have worked on has been the rebuilding of our crane motors to take ball bearings. One of these rebuilt motors using Fafnir bearings is shown in Fig. 1.

The need of careful selection, standardization of parts, improvement, and maintenance of equipment has led to the installation of record and other systems in the plants that have their own engineering departments. These systems vary in the method of recording in the completeness of the information kept on file, depending on how valuable they are considered by the organization, the extent of the co-operation received, and so on.

The system in use by the Hubbard Foundry Co. has been developed through experience covering quite a number of years, and although it is in use in a foundry and machine shop it has some points that may be valuable to those who are associated with other kinds of plants, particularly those in which inevitable interruptions must be cared for in the shortest possible time. In what follows regarding this system no effort will be made to present the details in logical order, but I shall attempt, rather, to bring out some of the features that may be of value to other industrial men who are responsible for the reliability of the plant equipment.

The organization for engineering and maintenance at this plant is really two separate organizations working in close co-operation. The engineering department under the chief engineer handles the plant and product engineering, estimating, construction work, and contract repair work. The actual maintenance work is under the supervision of the master mechanic, to whom the foremen of the various departments, such as the electrical, machine shop, millwright, carpenter and so on, report. While these are two separate organizations there is really that close co-operation which is necessary for the carrying out of the system we use as well as the actual work. The engineering for maintenance work is taken care of by the engineering department and usually the maintenance department assists somewhere along the line during a construction job.



INTERDEPARTMENT ORDER NO.

Date

Mr. Dept.

Please arrange to complete the following by

COMPLETED—DATE

For Dept. Equip. Reg. No.

Requested by Order No.

Fig. 3—This interdepartmental order is used on jobs estimated to cost less than $100.

This order is made out by the foreman of the department in which the work is to be done. The space in the lower right-hand corner is used for entering the equipment register number to facilitate easy reference to the original equipment record, Fig. 2, which will indicate the location of data that might be necessary for carrying out the order.

The selection, design, and installation of equipment and buildings, after the appropriation has been made, are left largely to the engineering department. This has been true for over 10 years, because of additions and growth it has been necessary for this department to keep in close touch with the equipment in the plant. On this account our system has proven invaluable.

Every plant should have an equipment register which should be kept up to date. It would be ideal if such a record could have been started when every plant was installed. Practically this equipment register would provide a continuous inventory of equipment and give the engineering, maintenance, and accounting departments reliable information on the location, life and condition of the equipment.

In our case no such valuable records were started with the plant but the need for them was felt as time passed, so about 2 years ago it was decided to set up such an equipment record. However, it required considerable labor and investigation to get the necessary data, but the effort has been well worth while. When all the available data were obtained, equipment register cards as shown in Fig. 2, were made out by the engineering department. These constitute the engineering record of equipment and from these cards the accounting department gets such information as is needed to set up the equipment ledger.

Each piece of equipment, building and so on, is given a number and all repairs or changes to it are charged to the equipment register number. The records show the department in which this piece of equipment is located and the proper departmental charges are made. For example, a repair to lathe No. L-32 would be charged to the machine shop and against that lathe. In this way not only is the proper department charged with the expense but a record is available of the cost of keeping each piece of equipment operating and there is no need for guessing at the condition. There is also other valuable information on the card such as the name of the manufacturer, equipment data, repair-part list, drive, cost, date of installation, depreciation, rea-

H-254 500 2-26 BF9035

ENGINEERING DEP'T. — EQUIPMENT RECORD

NAME — REGISTER NO.

LOCATION / TRANSF'R'D TO — DATE INSTALLED — F. O.

MANUFACTURER — PURCHASED FROM

MF'GR'S SERIAL — REPAIR PART LIST

DESCRIPTION

DRIVE — WITH

ESTIMATED LIFE — DEPRECIATION — PERCENT

COST—ACTUAL — APPRAISED VALUE — DATE

EQUIPMENT ONLY
FREIGHT
FOUNDATION
INSTALLING
TOTAL

DATE DISCARDED — REASON

DISPOSITION

REMARKS

Fig. 2—One of these equipment record cards is made out for each piece of plant equipment, and other property. These cards are made out by the engineering department and from them the accounting department gets such information as is needed to set up the equipment ledger. Also, all repairs are charged to the register number shown on the card. A record of these repairs and costs may be kept on the back of the card if desired, but such information is kept by the accounting department.

Fig. 4—Requisitions for repairs or new equipment costing over $100 are made on this form.

On any such repair jobs, this request for repair or equipment order ties in with the equipment register number. No work, except estimating, is done until approved by the engineering department which then issues the repair and equipment bill of material order.

son for discarding, and so on. Although this card might not, in its present form, meet all of the requirements in other plants, it nevertheless fulfilled our particular requirements.

In connection with this equipment register, we maintain a repair-part file in the engineering office which consists of catalogs, repair-parts lists, and such data as is furnished by the manufacturers of the various items of equipment in the plant. With this information, it is a simple matter to order the proper repair parts. In this connection, it is worthy of mention that not enough attention is paid by manufacturers of equipment to the furnishing of proper repair-part lists for the users of their equipment.

HUBBARD STEEL FOUNDRY COMPANY

REQUEST FOR REPAIR OR EQUIPMENT ORDER

CLASS_____ EQUIP. REG. NO._____

PLEASE ISSUE REPAIR OR EQUIPMENT ORDER TO COVER:- DATE_____

CLASSIFICATION OF REQUEST_____ ESTIMATE OF COST REQUESTED BY_____

REQUESTED BY_____ APPROVED BY_____ WORKS MANAGER

FOR DEPARTMENT_____ APPROVED BY_____ VICE-PRES. & GEN. MGR.

ISSUED BY_____ O. K. TO ISSUE ORDER_____ CHIEF ENGINEER

ESTIMATED COST OF ABOVE REQUEST

DETAILS	QUANTITY	PRICE	LABOR	MATERIAL	TOTAL

ESTIMATE APPROVED_____ CHIEF ENGINEER

If this request is for equipment that is to replace obsolete or depreciated equipment, it must be accompanied by REPORT OF EQUIPMENT RETIRED, Form H-315, in accordance with the standard instructions covering the retirement of equipment.

Fig. 5—Upon the approval of the requisition, Fig. 4, this bill of material and work order is issued.

This order covers the complete repair and overhauling of a crane motor, and describes the material required and the estimated labor cost. In the material specifications column are listed parts which must be purchased, together with the manufacturer's data to guide the purchasing department. Copies of this order are sent to the cost, purchasing, stores, engineering, and two copies to the master mechanic. When the job is completed, rescinded, superseded by another order, or otherwise closed, the perforated coupon in the lower right-hand corner is torn off and sent to the engineering department. When necessary, drawings are made up by the engineering department and sent to the department which does the work along with a copy of the order.

Some repair parts are purchased by us but since we operate a foundry and machine shop, we make such parts as we can economically, when time is a vital element.

Repair orders through the plant are handled as follows: if the expense involved is less than $100 for a job, the work is done on an interdepartment order, Fig. 3, which is issued by the foreman requiring the work done. If the expense is estimated at $100 or over it is necessary that a request for a repair and equipment order, Fig. 4, be sent to the engineering department to be properly approved.

The engineering department then issues the repair and equipment bill of material which is the order on which the work is done and from which the necessary material not in stock is ordered by the purchasing department. Accompanying this repair

HUBBARD STEEL FOUNDRY COMPANY

REPAIR & EQUIPMENT ORDER BILL OF MATERIAL

COM. BY ○ KH
CK. BY WFS
APP. BY JT

TO COVER: the cost of material and labor for the complete overhauling of M-86 on PL-5.

DELIVER TO: Machine Shop - (PURCHASING DEPT. NOTE: Deliver purchased material to Store Room - Notify F.Dean)

INSTRUCTIONS: PLEASE RUSH THIS ORDER!

R. & E. Order No. 257
Page No. 1
Date Issued Feb.3,1927
For Machine Shop Department
Equip. Reg. No. M-86/PL-5 Class
Requested By F.Dean
Approved By H.W.F.

	Drawing Number	Mark	Quantity	DESCRIPTION	Pattern Record	LABOR	MATERIAL SPECIFICATIONS
			1	Motor, M-86		Overhaul(complete) - Electrical Dept.	
			1 set	Armature Coils		Install - Electrical Dept.	Purchase
			1 "	Shunt Fields		Ditto	"
			1 "	Series "		"	"
			16	Carbon Brushes		"	"
○							The above material for Direct Current, type R-5, No. 2884, 21 Amp., 220 Volt, 5 H.P., 850 R.P.M., Milwaukee Electric Co.'s motor.

○ Date Order Completed

Copies of this B/M to the following: Cost, Pur., Stores, M.M.-2, Eng.

R. & E Order Number 257 Covering overhauling of M-86.

Was_____ On_____ 19__

Signed_____

DEPT. Crane — SUBJECT No. 13 A.E. — CARD No. 1 OF 1 — DRAWING No. Sk.1012

DATE	DESCRIPTION	MARK	MATL	NEW PRICE
7-14-20	#6 Gear	A-735-b	C.S.	
	REVISIONS			
8-14-25	A Retraced. Inside diameter of rim dimension added, pattern number changed from A-735-b to A-735-A.			F.D.

ENGINEERING DEPT. — PATTERN RECORD

PAT. NO.	DWG. NO.	NAME	WHERE USED	DATE
A-735	Sk.1610	Gear #4 - Bridge	Crane #6	9-25-23
" A	Sk.1012	Gear #4 - A.E.	Crane #13-15	8-14-25

Figs. 6A and 6B—Records of detailed drawings and patterns are kept on these two types of cards.

These are standard 4x6-in. cards with the necessary headings and spaces printed on them. The description of the revision made on a drawing is noted on the card instead of on the tracing. The pattern record shows every use which may be made of that pattern or of a revised pattern. For example, this gear pattern was used on crane No. 6 before revision and after revision is also used on cranes No. 13 to 15. The method of identification is explained in the text.

and equipment bill of material are such blueprints and specifications that may be required up to this point. In many cases, it is necessary that drawings be prepared before the bill of material, Fig. 5, can be issued. This, of course, delays the issuing of the order but if the drawings are available, that is, from a previous and duplicate order, the bill of material can be issued at once. In case machine-shop work is necessary a separate bill of material is issued setting forth the work that is to be done by the machine department.

An examination of the sample repair and equipment bill of material, Fig. 5, form will show how it is tied into the equipment register. You will also note at the lower right-hand corner a perforated slip, which the person who originally requisitioned the work or equipment is to return to the engineering department to show that the order is complete. The charges for the work are compiled against the repair and equipment order and disbursed by the accounting department when the order is complete.

The success of this order system is predicated on close co-operation of the maintenance and engineering departments. The ruling in the engineering department is that, once any information is obtained about a piece of equipment it is to be put in permanent form, either on a drawing or on file, so that it is available for future reference. This fund of information is of great value to the maintenance department as well as the engineering department and it is referred to constantly.

These two departments have worked out many improvements and have done much in the way of standardization of parts thus reducing the number of repair parts which it is necessary to carry on hand.

Drawings are made on standard-sized printed tracings; the following four sizes are used, 23 x 36 in., 18 x 24 in., 12 x 18 in., and 8½ x 11 in. Because of the bill of material order system, no bill of material is shown on the drawing. New prints are sent out with each order, thus eliminating the danger of using a print which does not embody the latest revision.

As far as practicable on detail drawings, only one important detail is placed on a drawing. This is done to facilitate the work in the shop. As a general rule, only one man works on an operation or a piece of work at a time and by having only one important detail or part on a sheet, the need for more than one man referring to the print at the same time, or, on the other hand, the sending to the shop of a number of prints of the same drawing is eliminated.

The detail drawings are very carefully indexed on printed 4 x 6-in. cards. One of these is shown as Fig. 6A. This card gives the name of the part, its location in the plant, mark or number, drawing number and date. Below are a number of lines for recording revisions. When a drawing is revised the only notation placed on the tracing is a letter designating the revision and the date of the revision with the checker's initials. All the data of the revision with its designating letter and date are placed on the index card only. This eliminates the crowding of the drawing with a number of revision notes which, usually, are never very clear. Sufficient space must be provided on the card for a complete statement of the revision. The cards are indexed by plant departments, customer, and class, and are thoroughly cross-indexed. This system has passed through several stages of development and has proven very efficient and satisfactory.

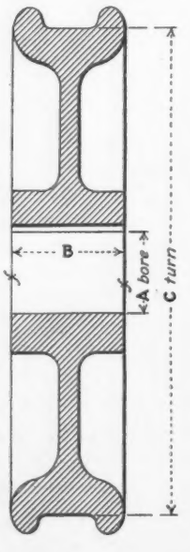
The drawings are numbered consecutively and filed in vertical files by size and number in a vault. Foreign blueprints, those obtained from manufacturers of equipment or other outside sources, are also filed in the vault.

Patterns are numbered, not by giving the drawing number and a letter as some companies do, but by a separate letter and number. Each pattern is indexed on a 4 x 6-in. card, which is shown as Fig. 6B. This is

Fig. 7—A page from the Crane Data Book.

The maintenance department is provided with a copy of this crane data book which is made up of 8½x11-in. blueprint sheets which contain the tabulated data collected for practically every piece of equipment which requires renewal or servicing on the cranes. The data are collected, and added to the original tracing, when a crane is taken down for repairs or renewal of the part and the dimensions taken from the original part. These valuable data are then available for any future repair.

HUBBARD STEEL FOUNDRY CO. EAST CHICAGO, IND. Sketch No. 1690



Scale

Dr. M.H. 2-24
Tr.
Ckd.
App.
Rev. A

CRANE	BORE A	LENGTH HUB B	TREAD DIAMETER C	TEMPLATE	KEYWAY	DRAWING
1	3⅜"	4½"	18"	T-2	⅜" x 3/16"	SK-377
2	4⅜"	4⅞"	18"	T-2	1¼" x 15/32"	SK-588
3	6"	4½"	24"	T-1	1½" x ¾"	SK-400
4	6"	4½"	24"	T-1	1½" x ¾"	SK-400
5	5 11/16"	10 3/16"	24"	T-1	1½" x ⅝"	SK-12
6	5 3/16"	12"	21"	T-1		SK-1655
7	3⅜"	4½"	18"	T-2	⅜" x 3/16"	SK-377
8	4⅛"	12"	18"	T-2		SK-781
9	3 31/32"	5 5/16" 5⅞"	20"	T-2	1" x ⅜"	SK-1294 SK-1702
10	5½"	5"	27"	T-2	1" x ⅜"	SK-1613
11	5"	4⅞"	24"	T-1	1" x ⅜"	SK-400
12	4"	4⅞"	24"	T-2	⅜" x 3/16"	SK-1035
13	4"	4⅞"	24"	T-2	⅜" x 3/16"	SK-1035
14						
15	4"	4⅞"	24"	T-6	⅜" x 3/16"	SK-1035
16	4"	4⅞"	24"	T-2	⅜" x 3/16"	SK-1035
17	6¼"	4 15/16"	27"	T-1	1¼" x ⅜"	SK-1707

BRIDGE TRUCK WHEELS

printed to carry the history of the pattern as far as changes or its possible use on other machines or equipment is concerned and is tied into the drawing index for other information relative to it.

The pattern-number system used is interesting. The original patterns are in series of 1,000 numbers. Suppose a gear pattern, for example, was numbered *D*-236. If this pattern could be used for another job with a slight change, such as larger hubs, which would not destroy the original pattern, the number would be changed to *D*-236-*A* by the suffixing of a capital letter. A second pattern change would be *D*-236-*B*. Suppose on another job the original pattern could be used but the finished gear had some slight change which could be made in machining, as for instance, a slightly narrower face, this would be given the original number with a small letter as a suffix as *D*-236-*a*, or in the case of changed pattern, such as *D*-236-*B*, being used with a machining change, the number would be *D*-236-*Ba*. The capital letter suffix represents a pattern change and the small letter a machining change. The identity of the original pattern is kept by the use of the original number.

This pattern-number system together with the cross indexing of details by class often enables the same drawing and pattern to be used for more than one piece of equipment. For instance by looking over the cards for gears we may be able to use a pattern we have for one job on a new job by making a slight change, and thus save the expense of another pattern.

As stated before, the engineering department is constantly trying to standardize parts and improve design so as to lessen the number of spare parts to be carried and reduce maintenance expense. In this work a great amount of information has been tabulated.

As this tabulated information is put in shape it is given to the maintenance department for their use. Having this data at hand lessens the uncertainty of their work and enables them to foresee their needs.

The use of this tabulated data is well illustrated by taking the cranes for an example. The maintenance department is provided with a crane-data book two pages of which are shown in Figs. 7 and 8, which contains the following information for each crane: motors and controllers, truck wheels, couplings, motor brushes, cables, gears and other parts. With these tabulated data, which are on 8½ x 11-in. blueprinted sheets, the correct parts can be picked out of stock for a repair job even without the detail drawings. Having this information also enables the maintenance men to make comparisons which assist in standardization of parts. It also assists them in keeping their stock of parts up to the correct standard, but if by some slip it should occur that a part is not available when needed, comparisons can be made and perhaps a similar part changed slightly to take care of the emergency.

Much attention has been given to improvement in design to lessen maintenance expense and keep the equipment ready to serve as nearly as possible 100 per cent of the operating hours. This, at times, has led to rather drastic changes from the original design. Referring again to cranes, which by the way are a source of continual watchfulness in a large steel foundry due to the hard use given them, often bordering on abuse, and the dusty conditions in which they must work, we have gone to the use of Cincinnati Tool Steel and Pinion Co.'s "Tool Steel" pinions and truck wheels; alloy steel shafts, steel couplings and ball-bearing motors.

We have been ridiculed about the ball-bearing motor idea in the past, but as our satisfactory experience extends over a period of about 5 years we believe we are not wrong. The

(Please turn to page 435)

Fig. 8—This is a repair-part page from the Crane Data Book.

The maintenance department may order a repair part by referring to this page from the data book, before they begin to dismantle the crane. If the part is in stock, it can be delivered to them immediately; otherwise, purchase or manufacture is ordered at once. An inspection of the data often indicates that a part intended for another crane may be used. The blank spaces indicate places where as yet the information has not been collected. These data are built up over a period of years.

DR. L.R.I. 8-7-23
TR.
CKD.
APP.

HUBBARD STEEL FOUNDRY CO.
EAST CHICAGO, IND.
SKETCH NO. 1156

GEAR DATA - CRANE No. 16 MAIN HOIST 10 TONS AUX. HOIST 3 TONS

	Gear No.	No. Teeth	DP	P.D.	O.D.	F_{Cs}	C_{Ps}	Lgth Hub	C-to-E Hub	C-to-E Hub	Dia Hub	Key-way	Patt. No.	Dwg. No.	Remarks
Main Hoist	1	22	4	5½"	6"	3¼"	2⅛"	3½"	1¾"	1¾"	4½"	½"x3/16"	S.F.	Sk. 1071	
	2	62	4	15.5"	16."	3"	2¾"	4"	2"	2"	4¾"	5/8"x3/16"			
	3	18	3½	5.143"	5.714"	3¾"	2¾"	4¼"	2⅛"	2⅛"	4"	5/8"x3/16"	S.F.	Sk. 1078	
	4	68	3½	19.429"	20"	3½"	3⅝"	4⅞"	2	2⅞"	6	⅞"x¼"		Sk. /—	
	5	15	2½	6"	6.6"	4¾"	3⅜"					⅞"x¼"	S.F.	Sk. 1077	
	6	65	2½	26"	26.6"	4½"	18¾"					¾"x¼"			
Aux. Hoist	1	18	4	4"	4½"	3¼"	1⅞"					½"x3/16"	S.F.	Sk. 1079	
	2	50	4	12.5"	13"	3"	2¼"	4⅛"	1½"	2⅝"	4"	½"x3/16"			
	3	18	4	4½"	5"	3¼"	2¼"	4¼"	2⅝"	1⅞"	3¾"	½"x3/16"	S.F.	Sk. 1080	
	4	86	4	21.5"	22"	3"	2⅞"	3⅜"	1½"	1⅞"	5⅜"	⅜"x3/16"	A-735-b	Sk. 1012	
	5	17	3½	4.857	5.429	3¾"	3⅛"					¼"x¾"	S.F.	Sk. 1013	
	6	74	3½	21.143	21.714	3½"	14¾"					⅝"x3/16"			
Trolley	1	14	5	2.8"	3.2"	2¾"	1½"					⅜"x⅛"	S.F.	Sk. 1072	
	2	41	5	8.2"	8.6"	2½"	1¼"	3⅛"	1⅜"	1¼"	3¼"	½"x3/16"	C-385	Sk. 1074	
	3	19	5	3.8"	4.2"	2¾"	1¾"					½"x3/16"	S.F.	Sk. 1073	
	4	46	5	9.2"	9.6"	2½"	1¾"	2⅝"	1¼"	1⅜"	3¼"	½"x3/16"	C-384	Sk. 1076	
	5	13	4	3¼"	3¾"	3¼"	1¾"					½"x3/16"	S.F.	Sk. 1075	
	6	52	4	13"	13.5"	3"	2⅝"	3¼"	1⅜"	1⅝"	5"	⅝"x⅜"	C-521	Sk. 1563	
Bridge	1	30	4	7.5"	8"	3 7/32"	2 1/16"					⅝"x3/16"	S.F.	Sk. 1337	
	2	66	4	16.5"	17"	3"	5½"	3⅛"	1½"	1⅝"	7½"	⅝"x3/16"	C-238	H-3343	Taper Keyway
	3	22	3½	6.286"	6.857"	3¾"	4½"	6⅝"	1⅞"	5"	5½"	⅝"x3/16"	S.F.	H-3343	
	4	82	3½	17.714"	18.285"	3½"	4¾"					⅝"x3/16"	C-236	H-3335	Taper Keyway
	5	15	2½	6"	6.6"	4¾"	3⅜"	8¼"	2⅜"	5⅝"	4¾"	½"x3/16"	S.F.	H-3335	
	6	45	2½	18"	18.6"	4½"	3 13/16"	4 13/32"	2¼"	2 11/32"	6¼"	⅞"x¼"	C-137	Sk. 1265	

BRIDGE-MILWAUKEE 10 TON No. 419 TROLLEY-MILWAUKEE 10 TON No. 418

Recent developments in

Electric Drives for Rolling Mills

By L. A. UMANSKY
Industrial Engineering Dept., General Electric Company, Schenectady, N. Y.

THE iron and steel industry is the largest single consumer of electric power. In 1924 this industry used more than 6,000,000,000 kw-hr., which is about 20 per cent of the total power consumed by all industries in the United States.

A modern steel plant, starting with iron ore as a raw product, produces at its blast and open hearth furnaces and at the coke ovens a large amount of waste gas or heat. Electricity gives means of conveniently converting and transmitting this potential power to the centers of its consumption.

So great is the demand for power in the steel industry that even plants having their own blast furnaces often purchase additional power from public utilities. Many other plants, deprived of the use of blast furnace gas, run almost exclusively on purchased power.

The bulk of this vast amount of energy goes for the work of shaping the steel. The rolling mill drives are the principal outlets of the generated power. Here the electric drive predominates. Hardly any new mills are being equipped with anything but electric motors. Older steam driven mills are being gradually electrified, for purely economic reasons.

Many electrical engineers, not connected directly with the steel industry, may not fully realize the profound, almost revolutionary changes which electric drive brought about in the rolling mills. It is not merely the question of performing the operations in a better, more efficient, or more reliable manner than otherwise possible; but the point, which is sometimes lost sight of, is that many operations and processes, now in wide use, are practically impossible without the agency of electric power. Rolling mill designers have taken advantage of the possibilities of electric drives and have built mills on radically new principles exceptionally advantageous for steel plants, but not practical, were it not for the presence of electrical motors. On the other hand, the electrical engineers have developed new machines, or new combinations of machines, primarily, if not exclusively, for rolling mill application. Thus the new rolling mill has become closely tied to its drive and is unthinkable without it. The influence between the electrical and mechanical equipments is now not only great—it is also mutual. New problems were brought up and many were solved more or less successfully.

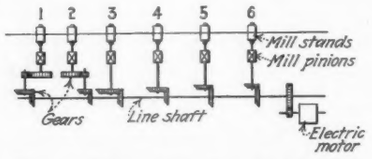


Fig. 1—Elementary diagram of a continuous mill with a single drive.
A number of two-high stands arranged in tandem and conventionally driven through a line shaft and gears by a single motor. The hot bloom or bar passes in succession through all stands, as indicated by the arrow. Each pair of rolls reduces the cross section of the bar until the latter leaves the last stand as a finished product of the desired shape.

It has been generally recognized that for a large tonnage output a continuous rolling mill possesses decided advantages. In this type of mill which is illustrated schematically in Fig. 1, the layout is compact; little heat is lost between stands; the metal is rolled at a high temperature and with a relatively low power consumption; the steel requires little, if any, handling; and also the labor costs per ton are reduced to a minimum. The bulk of the country's steel output passes through a continuous mill of one kind or another. To maintain the high tonnages and to keep the cost of handling down, the rolled bars are usually of considerable length; a finished length of several hundred feet is quite common. In order to save floor space the stands are located close to each other. This means that the metal is in several stands at the same time. It is obvious that with such an arrangement the speed of each consecutive pair of rolls is increased in proportion to the reduction of the cross-section area. For a given mill the speed relation between stands is fixed and is determined by ratio of the several gears; hence the reductions per pass, or the so-called drafts, are also more or less fixed. Thus, a continuous mill of the outlined type, capable of producing large tonnages of a certain class of sections, is not quite flexible when it comes to rolling a diversified line of products.

Individual drives for several stands of a continuous mill as shown in Fig. 2 give it the necessary flexibility, at the same time maintaining its inherent advantages.

If all motors, or several of them, are of the adjustable speed type, then the speed ratio between the stands may be readily changed. A wide variety of products may be then successfully rolled, each at its proper speed, each with the most suitable reductions at the several stands.

Mills, designed and built on this principle, are springing up all over the country. Hot strip, rods, merchant bars and certain structural shapes are being rolled on such mills. They are believed to be economical, flexible and tonnage producing. In many cases one mill of this type takes the place of two or three less modern mills.

This is an abstract of a paper that was presented by Mr. Umansky at a regional meeting of District No. 2, of the A.I.E.E., recently held in Bethlehem, Pa.—EDITORS.

Such layouts would be hardly feasible were it not for the application of the electric motor. We are inclined to accept it as a matter of fact, that there is no other device which can concentrate a large bulk of power in a limited space. It is efficient even in small units, is capable of speed adjustment, and will closely maintain its speed once it has been adjusted.

It is outside the scope of this paper and outside the competence of the writer to offer a thorough analysis of mill layouts from the standpoint of rolling mill operations. It was not intended to convey the idea that, for instance, a continuous mill with individual drives is the best combination or layout for all applications; such a mill was merely discussed in order to illustrate the profound influence of electricity on rolling mill engineering and practice. However, it will be shown presently how the electrical engineers are providing suitable drives for mills of the kind just described. While no radically new machine was invented nor introduced, some new combinations of machines were conceived and were successfully applied.

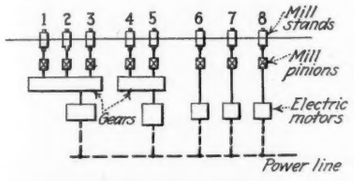


Fig. 2—Elementary diagram of a multi-drive continuous mill.

The first three roughing stands are driven by one motor, the next two stands by another motor and the last three, or finishing stands are each provided with a separate drive. The hot bloom or bar passes in succession through all stands, as indicated by the arrow.

When a mill requires a number of adjustable speed drives it is the simplest and, in many cases, the best way to make each drive a d.c. motor and to furnish power to them from motor-generator sets or from synchronous converters. The schematic layout of one of the most modern mills of this type is shown in Fig. 3.

All motors are 600-volt, d.c. machines and the power to them is furnished from three large synchronous motor-generator sets, aggregating 12,200 kw. (40 deg. cent. continuous capacity). Practically each motor has a corresponding generator, as is shown on the diagram. Ward-Leonard control is used for starting, and the combination of generator voltage and motor field control gives

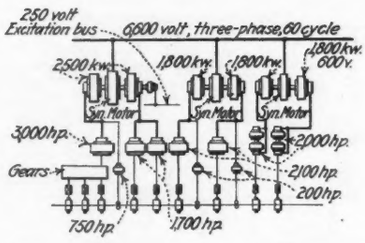


Fig. 3—This is a schematic layout of a large continuous mill driven by d. c. motors.

A 3,000-hp., 200/360-r.p.m. motor drives the roughing train of three stands; two 1,700-hp., 90/204-r.p.m. motors and two 2,100-hp., 150/460-r.p.m. motors are individually driving the next four stands; the two finishing stands are each driven by double-unit 2,000-hp. motors consisting of two 1,000-hp. armatures which can be connected either in series or in multiple and operating up to 800 r.p.m. Three smaller edging roll stands are also electrically driven.

a very wide speed range (as wide as 4:1 and 5:1) to each drive.

Another interesting example of a modern mill with stands individually driven by d.c. motors is represented by the layout in Fig. 4. The capacity of each drive is indicated on the diagram. The power to the motors is supplied from a 3,000-kw., 600-volt, three-unit motor-generator set. Ward-Leonard control is used for starting, and motor field control for speed adjustment.

The art of engineering thus far knows of but one way to built adjustable speed, a.c. drives, of such capacities as are involved in steel mill work. This is to use a slip-ring induction motor and to regulate its speed by acting on its secondary circuit in one or another well known manner. These methods have been described in great detail at various times and the most representative of them are diagrammatically shown in Fig. 5.

All these methods have one thing in common. An induction motor, running at a synchronous speed, delivers at its shaft as mechanical energy, only that portion of the power transmitted to the rotor which is proportional to the speed. The balance of this power proportional to the slip, is available at the slip-rings and is usually called the slip energy, which is of a frequency and voltage proportional to the slip. This energy is either converted into mechanical power and is returned to the main motor shaft, see Figs. *B, D, F,* or is converted into electric power of the line frequency and voltage and is returned to the a.c. system; see Figs. *A, C, E.* In the first case the drive is of a "constant horse power" type, as approximately the same amount or power (neglecting conversion losses) is available at the motor coupling at all operating speeds; in other words, larger torque is available at the reduced speed. In the second case the drive is of "constant torque" type, that is, the power available at the coupling varies with the speed.

In Fig. 5, *A* and *B* represent the Scherbius system employing an a.c. polyphase commutator motor *R* to convert the slip energy into mechanical power at its shaft; then it is either returned electrically to the line through an induction or synchronous generator *K,* or is utilized directly on the drive shaft. The regulating machine *R* is shunt wound and is excited from the slip-rings of the main motor. By controlling the amount of excitation the speed of the drive may be adjusted suitably.

In the Kraemer system, which is shown at *C* and *D,* Fig. 5, the slip energy is converted into d.c. power by means of a synchronous converter *G.* This d.c. power (of variable voltage)

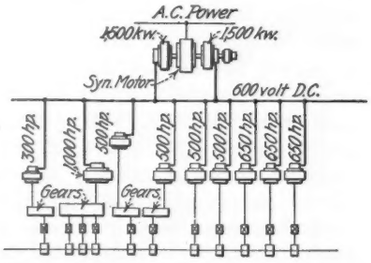


Fig. 4—Here is a typical arrangement of a moderate size continuous mill driven by d. c. motors.

The power to the motors is supplied from a 3,,000-kw., 600-volt, three-unit motor-generator set. Ward-Leonard control is used for starting and motor field control for speed adjustment.

may be also either pumped back to the line through a motor-generator set *N-K,* as in *C,* or returned mechanically to the main motor shaft, as in *D.* In either case the speed of the drive is adjusted by controlling the excitation of the motor *N.*

Or, the slip energy may be transformed by means of a frequency converter, *P,* which is shown in *E* and *F* in Fig. 5, running at the motor speed, and a regulating transformer, *T,* as in *E,* into line frequency and voltage. Finally, it may be converted suitably by a frequency converter, as in *F,* separately driven by a small synchronous motor, *A,* and is then returned as mechanical power to the main shaft by means of a synchronous motor, *S;* its excitation provides the speed regulating means. Several

other schemes, employing a frequency converter, are also conceivable.

Either scheme is capable of regulating the speed of the main motor not only below but also above synchronism, forming a so-called double range drive. Obviously the slip energy is then of a reverse direction; it flows from the regulating machines to the slip-rings, and not from them; the dotted arrows in Fig. 5 indicate that the flow of power will have to be reversed. The Scherbius and the frequency converter systems are usually of the double range type, on account of certain difficulties of operating the Kraemer drives close to synchronism (that is, at a very low frequency at the synchronous converter G) and of inability to go through synchronism under load, these drives are usually built as single range equipments, for sub-synchronous operation only.

It will be observed that with all of these schemes the main part of the a.c. power is converted but once until it reaches the mill coupling; only the balance of power or the slip energy goes through more than one transformation before it is utilized. Naturally, the over-all efficiency is higher than with the d.c. drives and is usually around 90 per cent at full load. The machines used for speed regulation should have a capacity depending on the size of the main motor and on the amount of speed range. Therefore, the greater the speed range, the more expensive becomes the a.c. speed regulating equipment, and the less becomes its advantage over a d.c. drive, both from the standpoint of first cost and efficiency. Obviously, with a double-range drive, the same speed regulating equipment is utilized to a greater extent than with a single-range drive.

While some of the outlined a.c. systems were widely used during the last 10 or 15 years, their application for multi-drive mills, gives the engineers an occasional opportunity to get off the beaten track, and to group the well known machines in some new and more advantageous arrangement. The underlying principle of several new combination drives is this:

If the slip energy, contingent on speed regulation of one or several a.c. drives, need not be returned to the shafts of these drives, it may be made use of for furnishing, completely or in part, the power required to drive some other sections of the same mill, or some other mills.

This principle was applied for the first time in 1925 in connection with the equipment shown in Fig. 6 and, to the best of the author's knowledge, it has not been suggested nor applied previously. The electrical engineers have solved the problem of selecting the drives for this mill in the following manner:

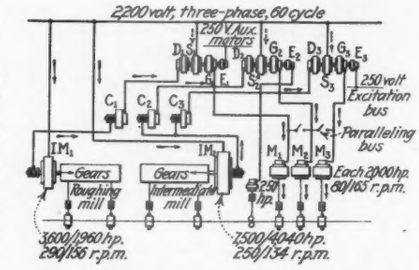


Fig. 6—Electrical arrangement of combination a. c. and d. c. drives for a large continuous mill.

This sketch represents a single line diagram of a large continuous rolling mill equipment recently put in operation in the Chicago district. For the sake of simplicity, the switching and control apparatus are not shown. The mill consists of several stands arranged in tandem. The roughing stands were to be driven by one motor, developing 3,600 hp. at 290 r.p.m. and 1,960 hp. at 156 r.p.m. The intermediate train was to be driven by another motor, developing 7,500 hp. at 250 r.p.m. and 4,040 hp. at 136 r.p.m. The three finishing stands were to be each driven by a 2,000-hp. motor, developing this capacity at any speed 85 to 165 r.p.m. A set of edging rolls required a 250-hp. drive. The electric power was available at 2,200-volts, three-phase, 60-cycle.

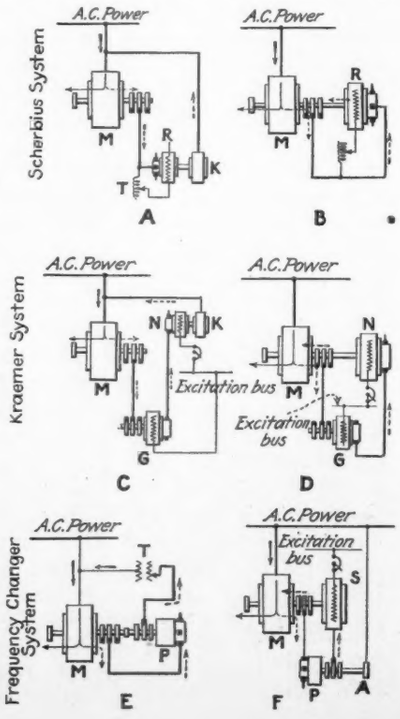


Fig. 5—Elementary diagrams of several a. c. adjustable-speed drives.

The slip energy is converted into mechanical power at the shaft or returned electrically to the line. A and B represents the Scherbius System, C and D, the Kraemer System; E and F represent the Frequency Changer System, wherein this slip energy goes through more than one transformation before it is utilized while the main part of the a.c. power is converted but once before it reaches the mill coupling.

The 3,600-h.p. and 7,500-h.p. drives, being large units running at reasonably high speeds, could be economically designed as induction motors, with speed adjusted by the Kraemer method. The finishing mill drives, smaller in capacity and much lower in speed, could be more advantageously and more compactly built as 600-volt, d.c. motors, with speed adjustment by motor field control. The power to these motors is furnished from three 1,700-kw. 600-rev. per min. d.c. generators, *G1, G2* and *G3,* driven by synchronous motors, *S1, S2* and *S3.* Low-speed, 60-cycle induction motors for driving the three finishing mills would be expensive machines with a rather poor power factor, and the use of reduction gears would not be very advantageous, nor feasible, due to certain local conditions.

It will be observed that the 3,600-hp. induction motor *IM-1* when running at 156 r.p.m. (that is, at 52 per cent synchronous speed), is required to develop only 1,960 h.p. as mechanical power at its shaft; the other 48 per cent or 1,640 h.p. are available as slip energy. The latter is converted by means of the synchronous converter *C1,* into d.c. power and drives a d.c. machine *D1,* as a motor. The excitation of the latter determines its voltage and, therefore, the speed of the drive *IM-1.*

Likewise, the 7,500-h.p. motor, running at 136 r.p.m. or 52 per cent synchronous speed, delivers to the mill 4,040 h.p., while the available slip energy amounts to 3,460 h.p. It is converted to d.c. by means of two synchronous converters, *C2* and *C3,* duplicates of *C1,* and is used for driving the d.c. machines, *D2* and *D3* as motors; by changing simultaneously the excitation of *D2* and *D3* the speed of the drive *IM-2* is adjusted. As the maximum amount of the slip energy to be handled by each of the machines *D1, D2* and *D3* is approximately 1,750 h.p., they are made exact duplicates of the 1,700-kw. generators, *G1, G2* and *G3.*

Arrows on Fig. 6 indicate the flow of power when the entire mill is in operation. It will be seen that the machines, *D,* are running as motors and are assisting the synchronous motors *S,* in driving the generators *G.* This assistance is the

greater, of course, the lower the speed of the drives *IM-1* and *IM-2;* if this speed is close to synchronism, or if the load on the drives *IM-1* and *IM-2* is relatively light, then the synchronous motors are more heavily loaded. In the extreme case they should be capable of furnishing the total power required by the generators and cover the friction and windage of the machines *D*. In other words, the synchronous motors need be only 50 per cent of the capacity required for a three-unit motor-generator set of the same d.c. rating.

Ordinarily, the motors *S*, would be running underloaded, providing an additional amount of leading kva., and compensating for the reactive kva. of the large induction motors. The power factor of the whole installation is approximately 97 per cent leading at full load.

Thus the slip energy of the constant torque drives *IM-1* and *IM-2* is not returned mechanically to the shaft of these drives where it was not required in this case, nor is it returned electrically to the power bus. Instead of this, it is made use of in a more direct manner; namely, for driving the finishing mills. The over-all efficiency is improved and the required capacity of the regulating apparatus is reduced to a minimum.

The drive just described possesses a number of secondary advantageous points, although these are not directly connected with the new principle of utilizing the slip energy. For instance, in case of light loads, it is possible to operate the drive *IM-2* with only one synchronous converter and one d.c. motor, say with *C2* and *D2*, and to operate the three d.c. motors *M1, M2* and *M3* from only two generators, say *G1* and *G2* by using the paralleling bus. This will permit the shutting down of one motor-generator set, thereby reducing the running-light losses. Although it is hard to estimate with any degree of accuracy the resultant saving in power, it is evident that any such saving is a net gain. It may be said in this connection that in steel mill drives, which are usually liberally motored to take care of the maximum load conditions, the low-running light losses are just as big a factor in conservation of power as the high efficiency.

Another continuous mill, now being built for a large eastern steel manufacturer, will be equipped with electric drives embodying to a smaller extent the same principle; several new features of a different nature

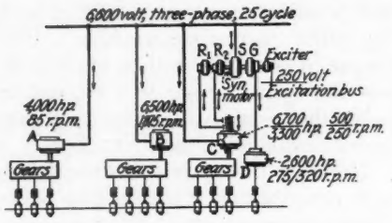


Fig. 7—Arrangement of electric drives for a large continuous mill. Two synchronous motors, one Scherbius equipment and one d.c. motor aggregating approximately 20,000 hp. continuous capacity will be used for driving this mill.

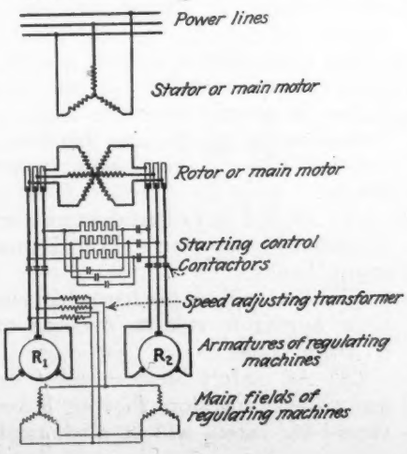
will make a brief review of this equipment rather interesting. In this case the mill will have a number of stands arranged in tandem, as shown diagrammatically in Fig. 7. The rolling requirements being different, the first several stands will be driven by constant speed motors. The power supply is 6,600-volt, 25-cycle.

The roughing train will take a 4,000-hp., 83.3-r.p.m. motor A, the intermediate train will be driven by a 6,500-hp., 187.5-r.p.m. motor *B*. The following group of stands will be jointly driven through a train of gears by an adjustable-speed equipment *C*, developing 6,700 h.p. at 500 r.p.m. and 3,350 h.p. at 250 r.p.m.

The last finishing stand will take a separate direct-connected drive *D*, with an output of 2,600 h.p. at a speed of 275 r.p.m.; constant-horsepower output will be maintained for speeds above 275 r.p.m. and reduced output on constant-torque basis, for speeds below this value.

These drives will never be required to start their respective mills with metal in the rolls. Mill friction on a cold winter day after a prolonged shutdown would be the most severe starting condition. Several tests have shown that a torque of about 25 or 30 per cent normal will start a continuous mill under most adverse conditions.

Fig. 8—Elementary diagram of electrical connections of a Scherbius adjustable speed drive with two regulating machines connected in series.



Actual experience with a 9,000-h.p., 107-r.p.m., synchronous motor, driving since the summer of 1926, a large continuous rolling mill at the McKinney Steel Company, Cleveland, Ohio, has proved conclusively that a synchronous drive is quite applicable for mills of this nature. This synchronous motor is capable of developing a starting torque of 265 per cent normal if started on full voltage. It is usually started on a low voltage tap of an auto-transformer, developing the starting torque actually required with considerably less than normal line kva. input.

Under the circumstances it has been decided to build the drives *A* and *B* as synchronous motors and to take advantage of their leading kva. for power factor correction of the steel plant.

The large adjustable-speed drive *C*, will consist of a 5,000-h.p., 375-r.p.m. slip-ring induction motor, the speed of which will be adjusted to 33 per cent above and to 33 per cent below synchronism (that is, from 500 r.p.m. to 250 r.p.m.) by means of the two Scherbius regulating machines *R1* and *R2*. With this constant torque layout, the capacity of the drive will be 6,700 h.p. at 500 r.p.m. and 3,300 h.p. at 250 r.p.m. An a.c. drive of such capacity and speed can be built more economically and with a much higher efficiency than any combination of d.c. machines. The fact that the power supply was 25-cycle gave the Scherbius system an advantage over the Kraemer drive.

The last finishing mill drive *D*, will have a wider speed range, is of smaller capacity and runs at a lower speed than the drive *C*. While a Scherbius equipment for the drive *D*, would be fully competitive in first cost, the difference between it and that of a d.c. was not as wide as in the case of the drive *C*. For the sake of greater flexibility of control it was decided to make the drive *D* of the d.c. type.

A 500-r.p.m. synchronous motor *S*, will drive a 2,300-kw., d.c. generator *G* (furnishing power to the motor *D*) and the two 650-kva. Scherbius speed-regulating machines *R1* and *R2* used for adjusting the speed of the induction motor *C*. When the motor *C* runs below its synchronous speed, the slip energy flows to the machines *R1*

and *R2;* the latter run as motors and assist the synchronous motor *S* in driving the generator *G*. In other words, the slip energy does not have to be returned as electric power to the incoming line; instead of this, it may be used for driving wholly or in part, the finishing mill *D*. The flow of power is indicated by arrows. This is another application of the same principle which was illustrated in Fig. 6.

When the drive *C* is running above synchronism, the slip energy becomes negative and arrows shown by the dotted lines in Fig. 7, will be reversed. The machines *R1* and *R2* act then as generators, and derive their power from the synchronous motor *S*. A direct-connected exciter provides the necessary 250-volt excitation to the synchronous motors *A, B* and *S,* and to the d.c. machines *G* and *D*.

The use of two regulating machines *R1* and *R2* for controlling the speed of the motor *C* presents some interesting features. The maximum amount of the slip energy to be handled by the speed regulating equipment is 1,700 hp. It is not practicable to build an a.c. commutator machine of such capacity to run at 500 r.p.m., so a lower speed such as 375 r.p.m. or 300 r.p.m. would be required. With the proposed layout such reduced speed would considerably increase the cost of the d.c. generator *G* and of the motor *S*. It would be still more expensive to provide a separate low-speed drive for the regulating machines *R1* and *R2,* and to drive the generator *G* by another 500-rev. per. min. motor. It was quite advantageous, therefore, to split the capacity of the regulating equipment in two units and to run them at 500 r.p.m.

The connections of the regulating machines to the secondary winding of the induction motor are shown in Fig. 9. The 5,000-hp. motor is equipped with six slip-rings, with both ends of each phase of the rotor brought out. Each set of three slip-rings is connected electrically to the commutator of the regulating machines *R1* and *R2,* which thus forms the two Y-points of the secondary circuit. In other words, the two machines *R1* and *R2* act as if they were connected in series with each other, their emf.'s added together. The shunt fields *F1* and *F2* are adjusted simultaneously by a common-speed control apparatus.

By disconnecting one regulating machine and by short-circuiting the corresponding set of slip-rings, it is still possible to operate the drive with the other regulating machine. Full torque of the drive will be obtainable, but the speed range will be cut in half; that is, it will be in this case approximately 312 to 437 r.p.m.

None of the several electrical layouts described on the preceding pages should be considered as anything more than what they were originally intended for: A good combination of electrical machines to fit a set of given requirements. Certain principles may be used again in some future drives. The whole combination may never be repeated. Electric drives for modern large rolling mills can hardly be standardized. They rather are and may be called "custom made," designed to fit individual cases.

Many single mills require up to, or over, 20,000 h.p. in electric drives; investment runs into several hundred thousands of dollars; the cost of power consumed in a year may approach the same figure. This alone justifies a thorough engineering study and a preparation of an individual layout for each case. Machines of special design need not necessarily be built for any new drive, but there is usually a broad field for working up a good new combination of apparatus.

It was the intention to point out, by means of the several illustrated schemes, that such an opportunity is present in most cases and that the electrical engineers seldom let such opportunities slip by.

Safety Rules for the Guidance of Crane Operators

AT ONE of the large iron and steel works, considerable importance is attached to certain rules governing the duties of the operators of cranes. In order that their operators may be at all times familiar with these rules, an enameled plate of these regulations, which reads as follows, is hung in each crane cage:

(1) No one but a regularly authorized operator is allowed to use this crane.

(2) You must thoroughly inspect your crane at the beginning of each turn and see that all bolts and nuts are tight, and that all chains and cables are in safe condition.

(3) You are forbidden to operate your crane when it is not in a safe condition; report immediately to your foreman on discovering any defects.

(4) Do not operate your cranes when anyone is working on your crane runway or any runway adjacent thereto, unless authorized to do so by the foreman in charge of crane repairs.

(5) Do not move without a signal from the proper man. See that the trolley is directly over the load, to prevent swinging. Be sure that every one is "Clear"; ring gong; start slowly.

(6) Do not carry load over men on the ground; use gong. Watch your empty hooks.

(7) You will be discharged if you allow anyone to ride on the load or on crane hooks.

(8) All safety devices must be maintained; operators showing a disregard for safety will be discharged. Keep your crane clean. Do not allow loose material to remain on it or on the runways.

(9) Do not leave your crane cab without first pulling out the main switch; when going up on top of the crane for any reason, put a red flag in open switch.

(10) No repairman shall make any repairs without first locking the main switch open and hanging a danger signal on the crane directly underneath work being done.

In an extreme case when the crane has to make a lift before repairs are finished, the craneman is thoroughly instructed by the foreman in charge of the shop or by the electrician. The operator will understand that each move to be made will be upon signal from the one who has just given him his instructions. The foreman or electrician will also see that each man on the job is in a safe place before signaling the craneman to move. In this case the lock on the switch is temporarily removed by one of the repairmen on the job and replaced by him when the movement is completed. Strict adherence to these rules has a tendency to lower accidents because definite responsibility is fixed for the movement of the cranes. The crane operator by virtue of these rules has certain authority in so far as the operation of the crane is concerned. The completion of any lift is dependent upon the one giving the initial instructions.

D. W. BLAKESLEE.
Electrical Engineer,
Jones & Laughlin Corp.,
Pittsburgh, Pa.

What will you be doing ten years from now?

FOR a number of years I have watched certain men grow out of small jobs into big ones with better salaries and larger responsibilities. Some of these men I have employed in their younger days, and others were acquaintances in whom I have been interested. What I want to tell you here is not why some men with a so-called pull succeed, but why every normal man with energy and ambition and an average brain can eventually grow into the position he would like to hold.

FIRST, it seems to me, as I have observed the progress of men who have accomplished things, that the *ego* in human nature must be suppressed. If you know you can handle a job, don't brag about it—just go ahead and do it and repeat the doing until the job itself and the way it is done will stand out as a particular characteristic of yourself. Next, don't be afraid to take on new responsibilities or new jobs. I always remember a remark by an old boss of mine after I had devised a new method that would save him time and money on a particular job. The method was good and he liked it, but it was developed too late to make full use of it. A considerable amount of stock already purchased would have had to be discarded to make the saving by the new method. This he explained to me with the comment: "We don't mind spending money on the idea of a live one if he can keep us from stumbling over the mistakes of the dead ones."

IN OTHER words, routine methods in a large plant need new and fresh thinking now and then, and the man who is closest to the routine is the one who has the chance to correct the mistakes of others and devise better methods of his own.

TODAY many machines that would normally last twenty years before being worn out are profitably discarded in half that time for more expensive machines, because of the kind of work they will do. And so it is with men who are given charge of a particular department or group of men and machines. I have collected several instances in plant work where operators have used their heads as managers as well as operators. For example, a plant engineer recently found that an electric hoist and one man would replace eight men and prevent considerable damage to the materials handled; so the hoist was installed. The general superintendent of a machine works by installing eighteen lift trucks and special platforms reduced the handling gang by fourteen men, with a total saving of $14,000 in handling costs the first year. A plant electrician, by getting the management to install pressure lubrication fittings on all bearings of motors and fans, reduced the cost of lubrication over 75 per cent and has not had a single case of bearing trouble in more than a year, whereas such troubles were formerly common causes of shutdowns.

IN ANOTHER plant, the chief electrician has demonstrated that push-button magnetic starters for motors have saved many times their cost in causing operators to shut off their machines when not in use, because the push buttons located on the machines make it easy for the operator to do this. Besides, the push buttons have saved much production time by preventing the running back and forth formerly required to operate hand starters mounted near the motors.

IN A recent issue of *The American Magazine,* there appeared an inspiring interview with Mr. Lawrence A. Downs, now president of the Illinois Central Railroad, who is the son of a section foreman of that road. Mr. Downs says he is simply an average person who has done things the ordinary man does, and about average well. But he has always kept his eye on a promotion and prepared himself to fill it. That has been the important thing in his life. These, according to Mr. Downs, are the seven essentials to regular promotion:

1. Do your stuff on the job you now have.
2. Let your boss know that you are dependable.
3. Avoid pockets and blind alleys, even if you have to quit a job.
4. Size up the job ahead of you and prepare yourself for it.
5. Don't overwork, but plan your work and don't waste time.
6. Don't over specialize, but balance up your accomplishments so that you can do several things well.
7. Be fair to yourself, your employer, and your associates.

IF YOU are wondering what you will be doing five or ten years from now, Mr. Downs' advice may make it possible for you to work out a very satisfactory answer to that interesting question.

Practical Pete

INDUSTRIAL ENGINEERING

Application and Operation of Electrical and Associated Mechanical Systems and Maintenance of Plant Structures

Published by McGraw-Hill Publishing Company, Inc.

G. A. VAN BRUNT, *Editor*

New York, September, 1927

We Have Changed Our Name

WITH this issue INDUSTRIAL ENGINEER changes its name to INDUSTRIAL ENGINEERING. The change is slight—merely the addition of three letters—but the new name expresses more exactly the field and scope of this publication. Its purpose is to present and to discuss from a practical standpoint the operating and engineering problems met with in the selection, installation, operation and maintenance of electrical and mechanical power drive equipment, and the equipment for furnishing such important plant services as lighting, material handling, heating and air conditioning, fire protection, and signaling and communication.

There will be no change in editorial policy beyond a broadening of the range of subjects treated that will enable us to serve more completely the industrial plant operating executive in all his various responsibilities.

Readers of INDUSTRIAL ENGINEERING are invited to submit the details of their operating problems to the editors for discussion and help, and to send in suggestions concerning the kinds of information that would be helpful to them.

A Statesman of Industry

WITH the passing of Elbert H. Gary, chairman of the board of the United States Steel Corporation, there was removed from the ranks of the great industrial leaders one of the most outstanding figures of this generation. Invested with tremendous power, as the head of the greatest industrial organization in this country, Judge Gary used this power with a wisdom, vision, and sense of responsibility that almost overshadowed his exceptional business judgment and genius for organization. The intelligence and character that won for him his victory over tradition developed into leadership that kept the industry free from internal strife and thus free to grow strong in public favor. As expressed by President Coolidge in his message of sympathy, "He stood foremost among those who find in the great private enterprises of our country an opportunity for public service as well as a medium for financial profit."

In truth, the outstanding achievements of the man were not the organization and eminently successful management of the great industrial enterprises which he conceived, but the fact that he used the power which his position gave him to put American business on a higher plane of service and conduct. Recognition of this fact was the keynote of the eulogistic messages, "He did most to restore conscience to business." "He led in the great movement to elevate industry to its present high plane of business and social morality and justice." "He stood for fair competition—he was the statesman of business," that came in a flood from the heads of business and industry.

To Judge Gary there came great power and with it almost boundless opportunities for service, both to the public and to industry. The constructive manner in which he used these opportunities won for him the admiration and affection of his associates, and a unique place in the annals of American business.

Check Up on the Location of Your Plant Service Departments

FREQUENTLY the men in charge of maintenance and other plant work fail to realize the advantages of a well-selected location for their headquarters. An inconvenient location not only wastes the time of the men in the department, but delays them in responding to trouble calls. The following incident shows the possible extent of this loss and also illustrates a method that other men can use to secure better locations for their departments.

In one plant two shops providing maintenance service were located in different corners of the plant yard at a considerable distance from each other, and about as far as they could be placed from the busiest sections of the plant, which naturally require the most service. In order to obtain a better location the head of the department kept a daily record for a week of the number of trips the men made between the shops and the various departments and determined the average distance for these trips. A similar estimate was made of the distance that would be traveled, assuming the men had responded from the desired location in the center of plant activity. It was thus found that the equivalent of two men's time was spent in absolutely unnecessary walking.

With these data the head of the maintenance department easily proved to his superior the advantage of moving his department to the new location. After making the change it was found that the force could be reduced by one man. Furthermore, supervision was easier, the men in the two departments co-operated better, a single storeroom was able to serve both shops, and a number of other economies were effected that in the aggregate made a worth-while saving.

Doubtless many other plants could with profit analyze the source of their trouble calls to determine whether more suitable locations, from the standpoint of convenience, could be found for their service departments.

Pushing Back the Limits of the Impossible

RECENT perfection by the American Rolling Mill Co. of a continuous rolling process for making thin sheets from ingots is one of the most interesting developments that has been made along this line for many years. It is also a good example of the fact that traditional methods are not always the best or most efficient, even though they may have been hallowed by years of use.

Until the present development few changes of consequence had been made in the process of rolling sheet, since the conventional method was worked out about 1750. Nor was it a simple matter to improve this process. A good many years of experiment and the expenditure of huge sums of money were required to bring the new process to its present form. Extensive research was necessary on the fundamental factors involved in rolling sheets, and many problems had to be solved before all of the details of the method could be worked out. Nevertheless, determination, backed by skillfully directed hard work, finally brought success, and the new process stands as a monument to all who played a part in its development.

Satisfaction with present achievements, whether these be personal or relate to the methods employed by an industry, may be a pleasurable indulgence, but it will never lead to lower production or operating costs. There is probably no method or piece of equipment used in an industrial plant that cannot, or will not, be radically improved within a comparatively few years. Pushing back "the limits of the impossible" is not an easy task, but that it can be done is being clearly demonstrated every day.

Let Your Lighting System Help to Cut Production Costs

WHEN artificial lighting is considered by plant operators on the same basis as other items of equipment used in production, the unit cost of the product is bound to be affected. In many plants there is at this time of the year a pronounced slowing up of production during the last half of the day. The reason for this will be found not alone in the physical exhaustion of the workers, but in the shorter period of daylight and the lack of efficient artificial lighting.

While there is time before operations must be carried on by lamp light in the early morning as well as the late afternoon hours, advantage should be taken of this opportunity to make any necessary changes or additions to the lighting system in preparation for the fall and winter production peaks.

If this has not already been done, it will be highly advisable to make a lighting survey of the plant. That is, the intensity of illumination at the working plane should be measured around machines and benches, as well as in stairways, storerooms and like places, to determine whether it is up to the standards that have been recommended as good practice. Such a survey is not difficult to make and it is almost certain to give some interesting results.

Needless waste of time could often be eliminated if the work were properly lighted, for one correct micrometer reading is worth a dozen guesses in the dark. The savings in the cost of material alone that is spoiled due to poor lighting may well equal the cost of improved lighting. Furthermore, in a well-lighted plant there is less danger of injury and fewer accidents, which is reflected in lower insurance rates, where compensation laws are in effect. Safety signs or posters are of no use if there is insufficient light to read the "Cautions" and the "Don'ts."

No plant operator can afford to ignore the fact that good lighting is a dividend-paying tool, as well as an effective form of protection against high production costs.

Every Employee Shares Responsibility for Fire Protection

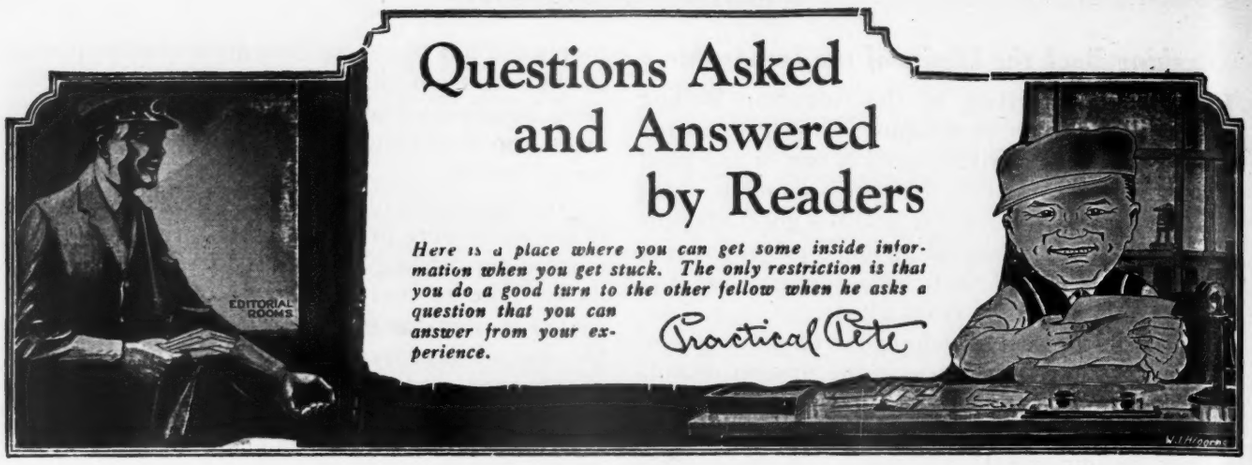
THE importance of adequate fire protection to the men employed in an industrial plant is well illustrated by the fire record of New York City for one month. During that period, as a result of 71 fires, 24 of the concerns affected failed, and a still larger number did not resume business.

Fire is one of the most serious hazards to industry because insurance ordinarily covers only the actual loss to property and does not compensate for interruptions to operation, delayed deliveries, or lost customers. Insurance never covers the lost time or the lost job of the worker.

The responsibility for fire protection rests upon the management of the company, but the workers are largely responsible for fire prevention. The management should provide adequate firefighting equipment, train the men in its use, and see that it is maintained in condition for instant service when the emergency comes.

The workers should co-operate by giving careful attention to good plant housekeeping, by compliance with no-smoking and other fire rules, by learning the hazards of the processes employed, by becoming familiar with the use of the firefighting equipment that is provided, and by learning what to do and what not to do when a fire suddenly breaks out.

In case of a fire both the workers and the management lose; therefore both must work together to prevent its occurrence. The men responsible for plant operation can do much to foster this co-operation. Furthermore, because of their familiarity with plant conditions they can and should suggest both means and methods of protection and prevention.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

QUESTIONS
Who Can Answer These?

Slippage With V-Belt Drives

I should like to have readers tell me what their experience has been with parallel V-belt drives, using rubber fabric belts on short centers. What is the difference between their operating characteristics and those of a rope drive? Can you give me any information on the coefficient of friction and minimum arc of contact? I understand that these belts tend to creep and have no slip. What happens when one or two of the belts stretch? I shall be gratified for any information you can give me.
East Pittsburgh, Pa. H. G.

Fastening Rotor Bars to End Rings

The heating of the rotor in one of our squirrel-cage induction motors during the starting period affects the soldered connections between the bars and the rings enough to make it necessary to resolder these connections about every 6 mo. Will readers tell me how to solder or secure the bars permanently to the rings so as to eliminate further trouble with them? If silver solder, or some other kind, is employed, I should like to know what flux to use, together with any suggestions you can give me on how to do the job.
St. Marys, Ont., Can. W. E.

Preparing Insulated Pipe For Painting

We are planning on painting our pipe lines but find that the covering on the insulated lines absorbs so much paint that several coats are required to cover it. I wish that other readers would tell me what they have used as a first coat of size to make such surfaces non-absorptive.
Rock Island, Ill. R. M.

Cause of Excessive Arcing at Motor Brushes

The brushes of the hoist motor, on our 15-ton crane, arc excessively. This is a 20-hp., 220-volt, 1,030-r.p.m., 80-amp., series-wound, d.c. motor with four interpoles and I am wondering if the trouble is due to the fact that it is operated from a 245-volt line. Although we have tried various kinds of brushes and have tested both the armature and field coils, excessive sparking persists after the resistance is cut out of the armature circuit by the controller, when either raising or lowering loads. I shall appreciate any information from readers that will help me to stop the arcing.
St. Louis, Mo. H. E. A.

Layout of Belt Drive for Waterwheel-Driven Generator

We are installing a 400-r.p.m. waterwheel to drive a 1,200-r.p.m., 100-hp. generator. The plans call for a drive pulley 60 in. in diameter with its center less than 10 ft. from the center of the 20-in. generator pulley. Both pulleys are 10 in. wide. We now have the pulley for the generator, but not for the waterwheel. Will readers please tell me (1) the minimum distance between pulley centers that could be used for this drive. (2) What width and thickness of belt should be used? (3) What kind or type of belt tightener should be used? (4) If the belt speed will be too high with the pulleys mentioned above, what sizes of pulleys can be used to drive the generator at the proper speed?
Allende, Coah., Mexico. L. N. S.

Safe Operating Temperatures For Magnet Coils

In view of our operating conditions I shall appreciate it if readers will let me know what they consider to be the maximum safe continuous operating temperatures for lifting magnet and magnetic clutch coils would with (1) single-cotton-covered enameled wire and (2) single cotton and asbestos covered wire, both with and without varnish treatment.
Ansonia, Conn. A. E. B.

How Does Change in Frequency Affect Transformer?

I should like to make use of some 60-cycle transformers on a 25-cycle circuit and shall appreciate it if readers will answer the following questions: To what extent will the change in frequency affect the output capacity, over-all efficiency and operating temperature of the transformers? Would thicker laminations increase the efficiency?
Muskogee, Okla. M. A. S.

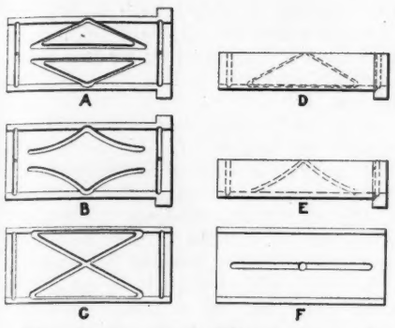
ANSWERS
Received to Questions Asked

Oil Grooves in Bronze and Babbitt Bearings

We rebuild our bearings and I wish that readers would tell me the best form of grooves to cut in oil-lubricated bronze and babbitt bearings up to 3-in. bore, for shaft speeds of about 300 to 1,800 r.p.m. I should like to know how grooves should be cut in both solid and split bearings. When should straight and when should criss-cross grooves be used? How wide and how deep should grooves be cut? How should grooves be cut for grease lubrication?
Scranton, Pa. B. V. W.

ANSWERING B.V.W.'s question, the function of channels cut in bearings is to convey the lubricant in sufficient quantity to the place where it is most needed.

A sleeve bearing will carry heavy loads at low and medium speeds with ordinary lubrication, such as rings or chains. According to the fancy of the mechanic who is cutting them, oil grooves may take many forms, some of which are shown in the accompanying illustration. The bearings shown at *A*, *B* and *C* represent three different types of grooves employed for oil lubrication. The bearing at *D* shows a babbitt-lined split-iron shell with a chamfered edge, which indicates the bottom half of the bearing. A bearing with a single goove cut in the bottom is best adapted for grease lubrication and this type is shown at *F*. I believe that the groove for oil lubrication should be about ⅛ the thickness of the bearing wall, and must not have any sharp edges to cut the oil from the shaft. In a babbitt-lined bearing the width of the groove should about equal the thickness of the babbitt wall. The bearing should then be chamfered where the oil ring discharges to the oil groove, providing a small reservoir for the channels to draw from. At the ends of the bearings a drainage channel should be cut at right angles to the length. One or



This shows several different types of grooves used in sleeve bearings.

more circular grooves are cut in the end of the bearing and each of these should have a small hole at the lower side to drain out the oil.

Drainage canals must be cut in the bearings of electrical machinery in order to prevent the oil from reaching the windings. These drainage canals are usually cut from $\frac{1}{8}$ to $\frac{1}{16}$ in. from the end of the bearings. The oil grooves must not be set closer than $\frac{1}{8}$ in. to the drainage groove, or the oil will run directly to the reservoir. In small bearings such as at *E*, one groove at each end of the bearing will be sufficient.

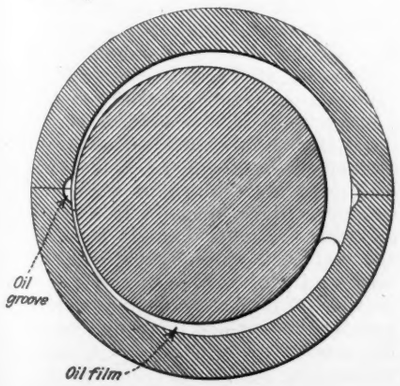
A gouge may be used for cutting these grooves, but an old, round file ground to the proper shape makes an inexpensive tool for this purpose.

A combination of rings and pressure lubrication is often used for speeds from 3,000 to 3,600 r.p.m. but the heavier machines are supplied with a separate oiling apparatus which is started before the machine. The lubricant is supplied under pressure to the bearings, so that ordinary slots are needed as oil channels.

Birmingham, Ala. GRADY H. EMERSON.

REFERRING to the question by B.V.W., there seems to be almost as many opinions and practices in cutting oil grooves as there are designers. The General Electric Company's method as applied to motor and turbine bearings seems to me to be a very good one.

This shows the approximate shape of the oil film in the lower part of a bearing.



For ring-oiled bearings, a longitudinal oil groove is cut along each side of the bearing, whether solid or split, on the horizontal axis, as shown in the illustration. These oil grooves are extended into the oil-ring slots of the upper half of the bearing and go to within $\frac{1}{4}$ in. to $\frac{1}{2}$ in. of the end of the bearing or of the circumferential oil-collecting grooves usual in motor bearings. The longitudinal grooves are made about $\frac{1}{4}$ in. wide and $\frac{1}{8}$ in. deep on bearings that are 1 in. to $1\frac{1}{4}$ in. in diameter, and the dimensions of the grooves are increased to about 1 in. wide and $\frac{1}{2}$ in. deep on bearings that are about 4 in. in diameter. These grooves should be flared out and have the edges rounded, as a sharp edge will tend to scrape the oil off the shaft. The rounded edges also facilitate the feeding of the oil to the bearing. Ordinarily an oil ring is needed for each 6 in. of bearing length.

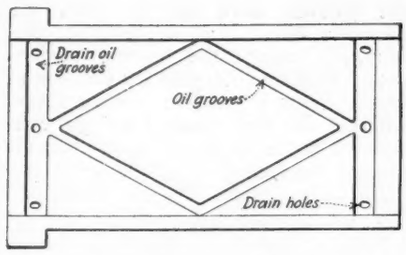
The arrangement of grooves for forced oil feed bearings in turbines is similar to that in motor bearings, a groove being located just below the split of the bearing on the side where the shaft runs down into the bottom half. The oil supply pipe is also connected at this point.

A general idea of the behavior of lubricant in a bearing may be determined from tests that have been made, which show that as the shaft turns the oil is drawn into the bearing and forms a wedge-shaped film under the shaft. The shaft is separated slightly from the surface of the bearing, the pressure on the bearing being greatest opposite the point of resultant pressure of the shaft. If grooves are located in this part of the bearing, they will relieve the pressure of oil formed under the bearings and consquently the lubricant will be allowed to flow out of the bearing instead of being kept where it is most needed. Therefore, it is evident that the real source of oil supply is due to the pumping action of the shaft pulling it into the bottom of the bearing. This action of the shaft on the oil may be considered to be the principle by which location of oil grooves is determined.

If for any special reason it is necessary to use grease in a bearing, the grooves along the top of the bearing should ordinarily be cut about twice the size of those recommended for use with oil. A compression grease cup or some other means of obtaining a steady flow of lubricant should be employed.

Plant Engineer, H. D. FISHER.
New Haven Pulp & Board Co.,
New Haven, Conn.

REFERRING to the question asked by B.V.W., there is a tendency among many mechanics to cut too many oil grooves in a bearing, on the assumption that the more grooves there are, the more lubrication the bearing receives and the less likely it is to heat. Actually, grooving should be done with the utmost economy in order to retain as much as possible of the bearing surface. Too many oil



This shows one way of cutting oil grooves in a bearing.

grooves cut in a bearing not only cause a reduction in the surface area, but the bearing is weakened.

The oil groove edges should be rounded off; otherwise the sharp edges are likely to wipe off the oil, and cause the bearing to heat. After a bearing has been used for some time it should be examined to see whether the wear on the babbitt has sharpened the edges of the grooves or closed them.

The accompanying illustration shows where to locate drain grooves and drain holes. The holes should be drilled in the lower portion of the drain grooves. These holes and grooves permit the oil to flow back into the oil well.

H. J. ACHEE.

District Line Supt.,
Southwestern Light & Power Co.
Elk City, Okla.

IN ANSWER to B. V. W.'s question, the surface speed of the shaft, load, and the length of the journal are the main factors that determine the cutting of oil grooves. On no account should oil grooves be cut too wide or deep, because wide oil grooves reduce the surface of the bearing, which may result in overloading. They should not be more than $\frac{3}{32}$ in. wide or $\frac{3}{32}$ in. deep as a rule, but these dimensions will need modifying according to the circumstances. Complicated oil grooves should be avoided, for in many cases

This shows method of lubricating bearings by cutting circular groove as in Fig. 1, and chamfering, as indicated in Fig. 2.

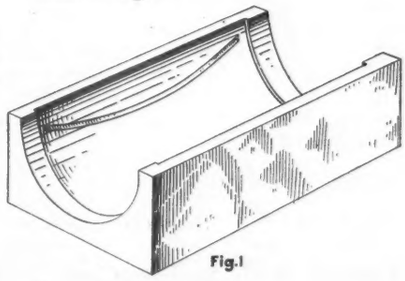


Fig.1

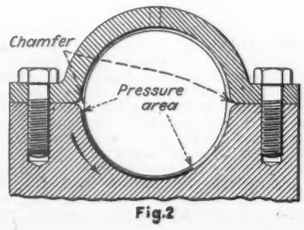


Fig.2

the grooves serve only to carry the oil from where it is needed and consequently reduce the bearing surface area. Bearings designed for slow-speed shafts always require oil grooves, whereas in high-speed bearings centrifugal force tends to carry the oil around the shaft; so grooving is not quite so important. To my knowledge the oil groove that has given the greatest satisfaction in practice is a curved groove, as shown at Fig. 1 in the illustration cut nearly to the ends of the bearings, or a curved groove which is joined by a straight groove. Spiral grooves have been employed for very long and small bearings. Oil grooves usually are cut only in the top half of the bearing where the oil is introduced but grooves may be cut in the bottom half so as to collect the lubricant and return it to be used again. Such grooves are seldom used, for if incorrectly cut they serve only to drain the oil from where it is needed.

For grease lubrication, grooves must be used, as grease has insufficient viscosity to work along the shaft under any conditions. A plain curved groove should be satisfactory. There is not much difference in grooves either for split or whole bearings, but it is essential that the edges of the groove be well rounded off so as to give a wedge-shaped entrance for the lubricant to the pressure area. The direction in which pressure is exerted as indicated in the illustration must be considered as the grooves should be located so as to introduce the lubricant to the shaft surface just before the pressure area is approached, as shown in Fig. 2 in the illustration.

In some instances chamfering, which consists of cutting away the edges of each bearing segment, gives better results than oil grooves. This provides a small, wedge-shaped lubricant reservoir which extends to within half an inch of the radius at each end of the bearing, as shown in Fig. 2. In many cases, no grooves other than chamfering are required, especially where the pressure is upwards. When the shaft oscillates or rocks, chamfering, which can be done only with split bearings, usually gives the best results. Criss-cross grooves may be necessary under special conditions, but to my knowledge and experience the groove shown in Fig. 1 has always given satisfaction, and can be used for most purposes in an industrial plant.

W. E. WARNER.
Shefford, Bedfordshire, England.

Trouble With Squirrel-Cage Motor

On a dust collector in our cement plant we recently had occasion to replace a 5-hp. motor with a very old 10-hp. motor that had been standing in our store-room for some little time. We desired to speed up the fan of a dust collector and thought that this motor would do it inasmuch as it was rated at 850 r.p.m., 13 amp., 10 hp., 440 volts three-phase. After installing the motor and starting it, the resulting speed on the motor was only 250 r.p.m. while the current per phase was 8½ amp. After taking the belt off the motor and dust collector and letting the motor run idle the speed went up to 770 r.p.m. while the current decreased to 6 amp. per phase. I have never seen a squirrel-cage motor behave quite in this manner and cannot understand how the speed can drop as low as 250 r.p.m. without the load current going up to even normal rating. There was no sign of heating no matter how long the motor ran. It occurred to me that possibly some one had tampered with the coil connections so I opened up the motor and found the stator to be connected single circuit star. Can any reader suggest why this motor behaved in this manner?
Detroit, Mich. R. W. B.

ANSWERING R.W.B.'s inquiry, I believe that the trouble he mentions is probably due to a defective squirrel-cage rotor. If the bars and end rings are carefully examined, loose or broken joints will probably be found; or if the rotor is of the soldered type, it may be found that most of the solder has been thrown out of the rotor joints.

In any event, if this rotor is defective it can be put into perfect condition by welding with an acetylene torch, using a good grade of cold-drawn bronze welding rod. R. K. HOKE.
Manager,
Keystone Electric Co.,
Baltimore, Md.

IN ANSWER to R. W. B.'s question, I consider the operation of an induction motor provided with a phase-wound rotor. This motor is started by the application of the normal operating voltage to the stator winding. Then the resistance, which is connected in series with the rotor winding through the slip rings, is varied until the motor starts up.

The motor will accelerate until it reaches a certain definite speed. It will run at this speed as long as this resistance is kept constant. Now, if a load is put on the motor, the motor speed will drop. The more load the motor is called upon to carry the greater will be the drop in speed. If it is desired to increase the speed of the motor at a certain definite load, it will be necessary to cut out more of the rotor resistance. If it is desired to obtain the maximum speed for a particular load it is only necessary to cut out the entire rotor external resistance. When this condition obtains, the motor will behave exactly the same as a squirrel-cage induction motor.

As R. W. B. states that the stator winding is properly connected, the misbehavior of the motor is due to a defective rotor. The resistance of the rotor winding of a squirrel-cage induction motor is fixed. The value of this resistance can be varied only during the process of manufacture or by extensive alterations.

As a matter of fact, the characteristics of a given machine can be changed markedly by providing it with rotors having different kinds of end rings. For instance, if the machine be provided with a low-resistance rotor, its slip will be low, its starting torque poor, and it will have a high starting current and a high pull-out torque. If the machine is fitted with a high-resistance rotor, the slip will be high, it will have a high starting torque, a low starting current, and a low pull-out torque.

The end rings are either bolted, welded or soldered to the rotor bars. The very best of workmanship is required in order to attach the end rings to the rotor bars, whatever the method, so as to obtain the proper resistance and avoid a poor contact between the rotor bars and rings. It is quite possible that due to unusual operating conditions, for instance, subjecting the motor to undue overloads for long periods of time, or to repeated starting under abnormal conditions, the rotor rings of a well-built motor may make a poor contact with the bars due to uneven expansion, melting of solder, or any other cause that would tend to increase the resistance.

That R. W. B.'s motor has a rotor with high contact resistance between bars and end rings is indicated by the fact that even at no load the speed is below what it ought to be, were the rotor in good condition. I am confident that if he will solder or weld the rotor so as to make good contact between the bars and end rings, he will find that the motor will operate satisfactorily. HENRY SCHERIL.
Brooklyn, N. Y.

IN REPLY to R.W.B.'s question, it would be advisable for him to check the size of the wire in the stator winding and then determine the proper connection. It is apparent, however, that the slip is excessive as the no-load speed should be approximately 900 r.p.m. if the frequency is 60 cycles, and the full-load speed should be about 850 r.p.m., according to the nameplate rating. Probably the reason for this excessive slip is that there are too many turns of a given size of wire in series and at 440 volts it is impossible to force enough current through the coils, due to the combined effect of resistance and reactance, even though the counter emf. is very low.

Therefore, it would be advisable to check the size of wire first in order to determine the proper connection. As it is stated that the motor is connected single-circuit star, and as the line current flows through each leg of the winding with this connection, the size of wire should be approximately 750×13 or 9,750 circ.mil or between Nos. 10 and 11 B. & S. gage.

However, if the size of wire is one-half this or 4,875 circ.mil, then the connection should be parallel star. If the stator were connected delta, the current per leg should be $13 \div 1.73$ or 7.51 amp. in each leg of the winding when the line current is 13 amp., and the wire size needed would be $7.51 \times 750 = 5{,}630$ circ.mil, which is quite near to a No. 12 B. & S. wire. It is possible that the winder intended to connect the machine this way, but made the error after bringing out the three-phase ends.

As R. W. B. did not designate the size of wire used, or number of slots, it would not be possible to state the proper connection accurately without going into the subject of design, but he could make a Prony brake test on the machine and determine the proper connection very accurately.

If when starting with a delta connection the speed falls below 850 r.p.m. at a 10-hp. output, and the current is below 13 amp., or if the starting torque is low, change to a parallel star connection. If this is unsatisfactory, then go to a parallel delta, and so on, until an output of 10 hp. and 850 r.p.m. is obtained with 13 amp. per phase at 440 volts.

In the above it is assumed that the frequency, voltage, coil pitch and the like are correct and the figure 750 is taken as the circular mils per ampere, although this figure may vary as much as 20 per cent.

Ordinarily in cases where there is sufficient time it is usually best to ask the manufacturer for complete winding data and check the machine from the designer's record. F. H. ROONEY.

Chief Electrician,
Columbia Steel Corporation,
Provo, Utah.

Changing Speed of Electric Drill

I have an electric drill that I wish to use for other purposes which will require a lower speed. The nameplate is missing, but the present no-load speed is about 1,800 r.p.m. and the full-load speed 1,200 r.p.m. The drill is driven by a universal motor and is capable of boring a ¼-in. hole in steel when operating from a 110-volt, a.c. circuit. Will some reader please tell me how I can reduce the motor speed to one-half or three-quarters of its present value? What is the principle involved in increasing or decreasing the speed of a universal motor?

Moline, Ill. J. M. M.

ANSWERING J. M. M.'s question, he will have considerable difficulty in trying to decrease the speed of the drill and still maintain the same horsepower, unless the motor is rewound. I do not believe this procedure would be warranted, if the drill is to be used for ordinary purposes.

On the other hand, the speed can be decreased by cutting resistance in the motor circuit. This method, of course, is not very practical from an economy standpoint. Even if this were done, the speed of the motor would not be decreased until a load was put on it.

Troy, N. Y. J. M. PETERSON.

ANSWERING the question by J. M. M., the speed of a series motor varies with the load and applied voltage. In this case full load reduces the speed of the electric drill, which operates on a 110-volt, 60-cycle single-phase circuit, from 1,800 r.p.m. at no load to about 1,200 r.p.m. at full load.

In order to reduce the speed of the drill further a resistance at suitable current capacity can be inserted in series with the motor. Although this method reduces the voltage at the motor terminals, it also reduces the power developed. Consequently, to operate the motor at the desired speed and still keep the load safe within safe working limits, the load on the motor must be reduced considerably as the speed is reduced.

H. S. RAMSAY.

East Kingston, N. H.

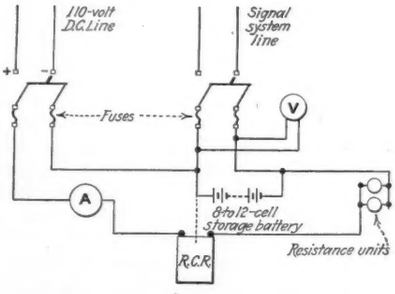
Reducing D. C. Voltage

Current for operating our signal systems is now supplied by two motor-generator sets; the demand on the generators varies from 15 to 20 amp. at 15 to 20 volts. We wish to discard our motor-generator sets and I should like to know of some suitable method of reducing the voltage on our 110-volt, d.c. service line so that we can operate our signal systems from it. It has occurred to me that a water rheostat might be suitable for this purpose. If so, can some of the readers give me the data for such a rheostat? Can anyone suggest a better method?

Chicago, Ill. M. G.

TWO methods will be suggested, in answer to M. G.'s question, in view of the fact that many signal systems operate intermittently in which case the actual number of ampere-hours consumed in 24 hr. is small. Also, reliability and freedom from power shutdowns are important considerations.

My first suggestion involves the use of an 8- or 12-cell, lead-plate, glass-jar, storage battery, or 12 Edison nickel-steel cells, which should be connected to the signal system as indicated in the accompanying diagram. The ampere-hour capacity of this battery should be equal to the signal system's demand over a 24-hr. period plus 20 per cent of this demand.



This shows how a storage battery that floats on the line should be connected to a signal system.

In this case the number of ampere-hours needed per day will, of course, govern the type of battery charger, which may range from a simple d.c. trickle-charger as used in radio work to a Ward Leonard resistance unit, or a lampbank in series with a double-pole switch and the battery. These chargers should be connected to the system at the point in diagram marked *resistance units*.

M. G. will find that the use of a reverse-current circuit breaker would be advisable, as it would prevent the discharge of the battery into the line in case of power failure, although it is not absolutely essential. If such protection is desired, it might be well to investigate a device made by the Fansteel Products Co., which is designed to serve the purpose of a reverse-current relay. If a relay is used it should be connected at the point marked *R. C. R.* in the diagram.

The amount of charge in 24 hr. should equal the amount of current used plus 15 to 20 per cent. The batteries should float on the line, holding the signal system voltage steady in addition to taking care of demands that are in excess of the charging current. When the demand from the signal system has ceased, or is low enough, the storage battery will absorb current from the 110-volt line.

All cells in the battery installation should be in series and the terminals should be connected positive to negative. Assuming that the negative side of the 110-volt d.c. circuit is grounded, the negative leg should be connected through 30- to 60-amp. fuses to the signal lines and system.

All battery connections should be scraped clean and bright before connecting, after which they should have a liberal application of cup grease or vaseline to prevent corrosion of the brass bolts and nuts or steel bolts and nuts if Edison cells are used. The cells should be placed in trays filled with sand or upon slate, glass or marble slabs that are insulated from the ground to avoid leakage of current.

A hydrometer or voltmeter check should be kept on the batteries to determine whether they are fully charged, or over- or under-charged. These checks will in turn enable the charge to be kept down to the minimum value necessary to keep the battery fully charged.

The above system, as outlined, is generally very satisfactory, dependable and economical, and the storage battery, if not overcharged more than twice a month or allowed to remain discharged for any length of time, ought to render 5 to 10 yr. of service.

There are certain precautions regarding the case of storage batteries that must be observed; namely, keep the water at the proper level; keep flames and sparks away from the cells; once a month pull the line switch for 12 to 24 hr. to discharge the battery; once a month, when no load is on the system as on a Sunday or holiday, step up the charging rate and overcharge the battery for a couple of hours.

A storage battery is much preferable to a water rheostat, which does not make a very satisfactory permanent installation, especially for this type of work. A. FIESS.

Tampa, Fla.

IN REPLY to M. G.'s question, I would not recommend the use of a water rheostat to step down the line voltage for the service, as suggested in the question.

On the other hand, I would recommend stepping down the line voltage of the 110-volt circuit by the use of counter-electromotive force cells, which

would be the most economical and practical for this service in the long run. The cells are made of lead composition grid plates that contain no active material. These plates are immersed in a solution of sulphuric acid of 1,210 sp.gr. at 70 deg. F.

The cells that I am most familiar with are manufactured by the Electric Storage Battery Co. of Philadelphia, Pa., and are known as the Type ET couple grids.

In this case as these cells are connected in series with the load and line current and the voltage of each cell is two volts, it will be necessary to use 45 cells, thus reducing the operating voltage of the circuit of the signal system to about 25 volts. The cells can be cut into the circuit on either the positive or negative side of the line. It must be remembered, however, that as the water in the cells evaporates it must be replaced from time to time and especially when the circuit is used quite frequently.

When the cells are first cut into service, it will be found that the voltage at the terminals of the signal system will not be lower than the line voltage, but after a very short time, the voltage will drop to the required 25 volts and after that the operating voltage will remain constant. In my opinion this is the most practical and economical method of solving the problem described in the question.

F. J. H. KRAUSE.

Dallas, Texas.

Polarity of Interpoles

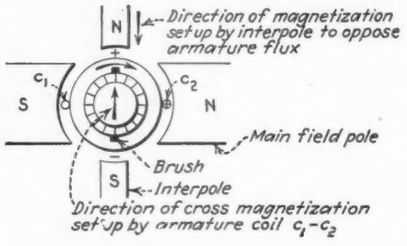
I do not thoroughly understand the rule governing the polarity of interpoles and wish someone would explain how it works out under different conditions. For example, on machines that have two interpoles, I have often found them to be of opposite polarity. Was this polarity correct? Can one rule be made to apply to a motor having any given number of main poles and interpoles? I shall be grateful for your help on this question.

Mohiland, Utah. K. W. F.

AN ANSWER to the question by K. W. F. can be more clearly understood by referring to the accompanying diagram, which shows the proper polarity for a two-pole generator. It should be noted that the interpoles in this case are of opposite polarity. The reason for this may be determined by noting the direction of the flow of current in the armature coil, which for simplicity is shown as one turn.

The current flowing through the coil produces a magnetic effect, which is neutralized by an equal and opposite magnetic effect produced by the interpoles whose coils are connected in series with the armature, and the magnetic section so proportioned that the field set-up practically varies directly in value with the armature current. It should be noted that the preceding interpole is of the same polarity as the main pole.

K. W. F. can clear up the question in his mind further by dividing a circle into any equal number of parts and assuming them to be main poles. Then by applying the rule that in a generator for a particular direction of rotation an interpole of the same polarity precedes the main pole, it will be seen by inserting the correct interpoles that those diametrically opposite will always be of the same polarity, the only exception being in the case of a two-pole machine. Here the diametrically opposite poles are of opposite polarity.



This shows the relation between the polarities of the main poles and the interpoles in a two-pole machine for clock-wise rotation.

For a motor, an interpole has the same polarity as the main pole it follows, assuming, of course, the same direction of rotation.

C. OTTO VON DANNENBERG.

Electrical Division,
General Engineering & Management Corp.
New York, N. Y.

REFERRING to K. W. F.'s question, the object of using interpoles on direct-current generators and motors is two-fold. First, to improve commutation by eliminating sparking due to changes in load and second, to accomplish this effect automatically rather than manually, which is the case with non-interpole machines in which the brushes must be shifted as the load is varied.

The interpole winding is made up of a few turns of heavy copper and is conected in series with the armature. As in the case of machines with series windings, the strength of the interpoles is adjusted by means of a shunt, which diverts a portion of the armature current, in case the interpoles are too strong.

In direct-current generators or motors provided with interpoles, if the armature has a multiple-circuit winding there are as many interpoles as there are main poles or brush arms. If the armature has a two-circuit winding, in which case only two sets of brush arms are used, only two interpoles are required. A railway motor is a good illustration. The armature has a two-circuit winding; and the motor may have four main poles, two sets of brushes and only two interpoles.

Although the machine is provided with only two interpoles, they must be of unlike polarity. This must necessarily be so, because the windings of the interpoles are so connected that the currents in the two interpole windings flow in opposite directions, thus producing a north interpole and a south interpole. Furthermore, the magnetic circuit is made from one interpole to the other and that can be accomplished only when the two interpoles are of opposite polarity.

The general rule for the polarity of interpoles is as follows: Assume clockwise rotation. Then, for a generator, the interpole next preceding the main pole is the same polarity as the main pole; for a motor the interpole next preceding the main pole is of opposite polarity to the main pole. In other words, in a generator, a main north pole will precede a north interpole and in a motor a main north pole will precede a south interpole.

HENRY SCHERIL.

Brooklyn, N. Y.

Installing Anti-Friction Bearings in Sleeve-Bearing Motors

We have a large number of induction motors of modern design, ranging from 10 to 75 hp. in size, that are fitted with ordinary sleeve bearings. Many of these motors operate in a very dusty place and considerable trouble has been experienced from rapid bearing wear. On all of our motors we have had trouble with oil slinging, which has caused a number of failures. For these reasons we are considering installing ball or roller bearings. Accordingly, I shall appreciate it if readers will tell me (1) their experience with these bearings and (2) give me some information on how to install them in place of the present babbitted sleeve bearings. (3) Can you give me any data on the cost of making such a change?

L. M.

Joplin, Mo.

REPLYING to L.M.'s question, my experience with roller bearings has proved that they are unequaled for use in dirty locations. On five 1,000-r.p.m. motors, the largest having a rating of 33 hp., on a slag pit crane, sleeve bearings had to be changed every six or eight weeks. due to the fine particles of slag working into the roll and cutting out the babbitt in the bearings.

Roller bearings were installed on these motors 3½ yr. ago, and since then there has not been a case of bearing trouble, although this crane is used 365 days a year. A direct saving is made on lubrication as these bearings need only a very little grease every few months.

The absence of grease or oil greatly lengthens the life of windings. All these motors are gear-driven and are subjected to very rough handling, as they frequently operate on heavy overloads.

If L.M.'s induction motors are of recent design it is quite possible that the sleeve-bearing end bells can be exchanged for new ones equipped with anti-friction bearings. Some machine work on the old shafts will be required. This work can usually be taken care of in any machine shop without removing the shaft. There are times, however, when it may be desirable to purchase a new motor shaft.

Several manufacturers of anti-friction bearings are prepared to supply bearing housings with their bearings, which can be placed in the old end bells after the sleeve-bearing housing has

been machined out. Such changes are frequently made on standard motors.

As some motor designs are more adaptable to anti-friction bearings than others, it is difficult to estimate the cost of a change over. In cases where the old end bells can be machined out to receive the anti-friction bearing with its housing, and the shaft can be turned to suit the bearing bore, a 15-hp. motor can be changed from sleeve to roller bearings for about $66.

Chief Electrician, O. C. CALLOW.
Trumbull Cliffs Furnace Co.,
Warren, Ohio.

Method of Removing Wires from Semi-Closed-Slot Motors

I shall appreciate it very much if some of the readers will tell me the best way to strip the stators of small series motors having semi-closed slots. I have seen a great many repair shops burn the insulation so that the wires come out easily. Does this in any way damage the iron or the insulation between the laminations? Can you advise me of a better method? Also, I should like to know the number of dippings and bakings that are necessary to make a first-class job on a motor.

Rome, Ga. M. S. C.

THE simplest method for M. S. C. to use is to burn the insulation off. This can be done by sending a strong current through the stator with the motor dismantled. If the insulation catches fire, let it burn long enough to char it.

As regards the effect of the heat on the iron, if it is not chilled too quickly or not allowed to become red hot and cooled quickly, so that the iron becomes hard and brittle, the core iron will be left in satisfactory condition. The writer has rewound quite a large number of stators and armatures that have been through fires, and they have worked satisfactorily.

Regarding dips and bakes, one long-soak dip and a long bake will be found satisfactory for general use, but more dips and bakes can be given to meet various conditions, such as would be necessary to make the machine oilproof, or moisture-, acid- and alkali-proof. For these more severe working conditions, from three to five dips will be necessary, depending on the varnish used and the severeness of the motor service. A. C. ROE.

Renewal Parts Engineering Dept.,
Westinghouse Electric & Manufacturing Co.,
East Pittsburgh, Pa.

IN REPLY to the question asked by M. S. C., it may be of interest to know that we strip the old windings from semi-inclosed slot motors by removing the rotor and applying 200 per cent of load current to the winding to be removed, but we do not permit the defective motor winding to become dangerously hot.

The minimum temperature that will satisfactorily loosen the varnish and cell insulation so that the old coils can be removed can best be found by practice.

We do not have any trouble from excessive temperature damaging the laminations, particularly if the original winding was dipped and baked, as the coils can be removed from the slots after the varnish softens. The coil ends can be cut off with a bolt cutter, or other similar tool, and pulled out endways or through the top opening in the slots. We find that this method leaves the slot insulation in good condition to be removed.

We bake all our rewound equipment as follows: The new winding is heated to about 70 deg. C. in a baking oven and immersed in a vat of good baking varnish, preferably one having a china-wood oil base. After immersing for about 10 min., it is removed and all excess varnish permitted to drain off. It is then put in the oven to bake for 12 to 18 hr. at 110 deg. C. The part should be watched from time to time during the baking period to see that pockets of varnish do not accumulate at any point on the winding.

It is very necessary that the specific gravity of the varnish be maintained at the proper value, and it is best to use a thinner recommended by the manufacturer of the varnish.

Chief Electrician, J. S. MURRAY.
Follansbee Brothers Co.,
Toronto, Ohio.

REFERRING to M.S.C.'s question, I would first heat the motor in an oven or in some other appropriate way, until all the insulation becomes soft. Then the wires of every coil should be cut off at both ends, with a wire cutter, chisel, or saw. After drawing out the retaining wedge, one may easily pull out that part of the coil that remains in the slots without damaging the core. Before trying to drive out the wedges, tap them sharply, as this will loosen them. Before dipping, the motor should be baked for 8 hr. in an oven at a temperature of about 200 deg. F.

After this operation, allow it to remain in the baking varnish for about 15 minutes or until bubbles cease to rise to the surface of the varnish. After a motor has been dipped in baking varnish and removed, it is essential that the excess varnish be allowed to drain off before baking. If this is not done, and the motor is baked in a horizontal position, the excess varnish will run to the low side and harden, thus causing the armature to run out of balance.

When a rotor or stator is put in a fire to burn off all the insulation, the varnish that is between the laminations in most motors is often destroyed, thereby causing eddy currents to circulate through the iron, when the motor is operating, and reducing its efficiency.

The baking process should be carried on for about 48 hr. at 200 deg. F. One dipping and baking is sufficient in most cases, but when service conditions are unusually severe two dippings and bakings are necessary.

H. J. ACHEE.

Superintendent,
City Water & Light Dept.,
Elk City, Okla.

ANSWERING the question by M. S. C., we prefer to remove wires from semi-closed slot stators in the following manner:

With the exception of one coil which is kept as a sample coil, we chop the coils off close to the laminations by means of a cold chisel and hammer on the side that they are connected. We do this first in order to free all connections.

Next, set the stator down with the cut ends of the coils next to the floor, and with a small pinch bar pry out each coil separately. By holding the hand over the nose of the coil you can pull out the top and bottom of the coil at the same time. Sometimes, if the coils are in very tight, it may be convenient to bolt the stator to the floor so that both hands will be free to work. On big stators we generally find it necessary to pull out the coils with a fast-operating chain block.

On armatures and stators that are made up of fine wire, we find it best to dip the coils in a lye tank to loosen the insulation. Boil for about 4 hr. in this solution, and then take part out of the lye tank and allow water to run over it in order to wash out the lye remaining on it.

After clipping the ends of the coils with a pair of end nippers, or tin shears, you can now easily pull the coils out from the other end of the slots by hand, and the insulation will also be loose in the slots. On armatures that are thus treated, it is best to remove the commutator before immersing in the lye solution or, if the commutator is difficult to remove, hang the armature in the tank in such a way that the commutator will not be in the lye. In order to keep the vapors away from the commutator, wrap a few turns of friction tape around the bars.

We consider burning out the coils or heating them with a blowtorch to be bad practice, as it is necessary to get the core nearly red hot before the wires in the slot loosen up, and this heat injures the coating of japan on the laminations. After the coils are removed, considerable difficulty is experienced in removing the insulation, for it sticks to the slots.

In regard to the baking of armatures and stators, it is good practice to preheat them before they are dipped in varnish in order to dry out the moisture, as the varnish seems to saturate the insulation better when the coils are hot than when they are cold. I find it better to bake armatures and stators longer and at a lower temperature than many winders do, for by so doing the volatile solvents in the varnish are given a chance to escape before the outside of the varnish is baked very hard. Generally, one dipping it sufficient for ordinary service, if a good coat of air-drying paint is used after baking. When the machine is to be used in chemical plants or outside work, we always dip and bake twice and then apply two coats of air-drying paint.

NICHOLAS J. WEISS.

West New York, N. J.

Electrical Service

AROUND THE WORKS

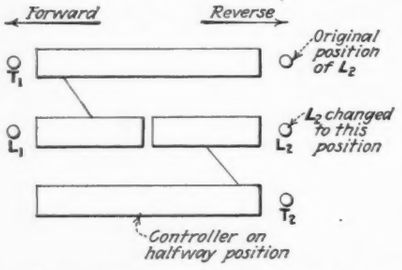
For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Trouble With Controller Due to Improper Assembly

A THREE-PHASE, 440-volt, hoist motor and drum controller, which had been recently installed, would not operate properly even though an experienced electrician on the job had checked all connections.

The drum controller was for both forward and reversing duty. The motor ran normally in the reverse direction, but the fuses were blown when the control handle was pushed ahead for forward operation.

After all the connections were checked



This diagram indicates change made in the location of the drum-controller contact fingers.

un. I sat down and watched the contact fingers make and break contact as the controller handle was moved through the forward and reverse positions. When the handle was moved into the reverse position it appeared to me that the segments on the controller were correctly located, but one of the contact fingers was not, thus causing a short circuit. So, as indicated in the accompanying diagram, contact finger L_2 was moved down one space in order to make contact with the middle segment. The motor then ran properly in both forward and reverse directions.

GRADY H. EMERSON.
Birmingham, Ala.

Changing Overload Protection to Meet Service Demands

AT ONE of our mines we have a 400-kw. and a 200-kw., 2,300-volt, steam-driven generator. As our day load requires the use of both of these units, the circuit breakers have to be set for the combined output of the generators. Our night load calls only for the 200-kw. unit and naturally our feeder circuit-breaker setting would be too high to give any protection to the small generator. If a trolley wire became grounded, or a heavy overload came in on the line, it would almost stop the generator, perhaps causing a fire by burning out bonds or causing damage to motors from low voltage.

In order to eliminate this danger we devised a way of installing an extra relay on each feeder, using the same current transformers, by setting one relay at 80 amp. and the other at 260 amp. These relays are thrown in or out of the circuit by a reconstructed G. E. contactor and are energized from the exciter current of the 500-kw. set.

When the turbine bus switch is closed the circuit for the contactor is automatically closed, which, in turn, connects the 260-amp. relay and the plant is ready for the day's work. When the turbine switch is opened, the contactor falls out and connects the 80-amp. relay for the 200-kw. set. H. BANHOLZER.
Electrical and Mechanical Engineer,
Knox Consolidated Coal Co.,
Bicknell, Ind.

Incorrectly Assembled Dashpot in Compensator Cause of Operating Trouble

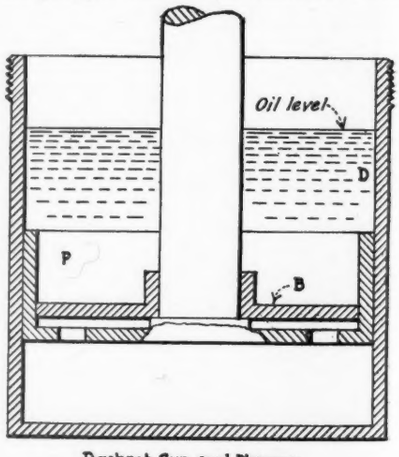
WHEN trouble occurs with industrial equipment there is always a reason, and a continual recurrence of the same trouble indicates that the cause of the difficulty has not been located. The need of a thorough, instead of a superficial investigation under such circumstances is well shown by the following experience.

On machine shop planers the greatest load occurs at the points of reversal of the table under average working conditions, although this is not true when cuts up to the extreme capacity of the planer are taken. It is at these peak points that belts squeak in time-honored fashion and here also that fuses are blown by the heavy current drawn, should an individual motor be underfused.

The largest planer in a shop manufacturing railroad equipment is driven by a three-phase, induction motor controlled by a compensator. After this drive had been in for some time, the no-voltage release gave trouble and an electrician adjusted the nuts on the dashpot rods to the limit for the fuses used. Soon the release showed that it was "tender" again and after several superficial examinations failed to locate the trouble, the planer hand adopted the scheme of blocking the starter lever over with a stick.

The planer was operated with this makeshift until it was noticed by a new foreman. This time another electrician was detailed to the job.

Unscrewing the dashpot, he noticed that it was less than half full of oil. It had been in that condition when the other men looked at it, but they had assumed that it was full enough, because the plunger was always immersed when



Dashpot Cup and Plunger

The baffle disk *B* in this dashpot was inserted upside down.

This condition and the low oil level in the dashpot were apparently the cause of continual trouble with the no-voltage release relay.

the contacts were closed. This man reasoned that a certain amount of oil was necessary above the disks in order to secure the proper action, and filled the cup to the level shown in the diagram with motor oil, as no other oil was available.

In the diagram *D* represents the dashpot cup and *P* the plunger. Filling the cut with oil helped, but did not overcome the trouble entirely. He changed the adjustment on the rod to the point where the switch would not stay in, and then adjusted the nuts until a good working position was reached without approaching the fuse capacity. Because of the difficulty of finding this position he investigated further.

He then found that the baffle disk *B* inside the plunger was turned upside down. Evidently someone who had

taken the apparatus apart had turned it over. This disk has a hub projection on one side and no hub on the other to govern the free passage of the oil. Putting the disk in as shown in the diagram gave an adjustment that appears to be perfect in that at the instant of reversal on the planer, the contacts ease off just enough to take up the mechanical play in the parts and then settle back.

This controller has worked satisfactorily ever since, which goes to show that a piece of equipment will do what it has been designed for, if given a chance.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Wrong Connections Cause of Motor Heating

A RATHER peculiar case of motor trouble occurred recently in a local plant. This motor had been taken down six months previously and placed in storage, and was to be mounted again in the original location. It was a three-phase, six-wire, 550-volt, 10-hp. machine, and was equipped with a star-delta starter. Both motor and starter were manufactured by the Crocker-Wheeler Co.

When power was applied and the starter handle thrown to the starting position, the motor hummed, but refused to operate. The line fuses were good; so the starter was examined, and the star point, which in this type consists of three segments short circuited by a brass rod, was found to have one segment open. When the rod was put into place again, and power applied, the motor instantly started and came up to speed. However, on throwing the starter handle to the running position, the motor gradually came to rest and began to heat up. The slackening of speed was a warning; so the switch was pulled and a large flash indicated an excessive current.

The rotor was examined for loose rotor bars, but they were in good condition. The motor was assembled again and started normally, but when the starter handle was thrown to the running side the motor immediately began to heat again.

As a last resort, the phases of the motor were rung out and each phase was tagged on both ends, regardless of the connections indicated on the motor diagram. Having located both ends of the three phases, one end of each phase was connected to the start side of the starter as previously tagged. This was accomplished by dropping the starter case, holding the handle in the starting position and tracing through the connections. The other three ends were connected to the remaining three wires from the running side. When power was applied, the motor came up to speed and when the handle was thrown to the running position, the motor settled down into its normal stride. It has operated without the slightest trouble ever since these changes were made.

Later, it was discovered that the man who took the motor down cleaned it and painted the leads previous to placing it in storage. In order to paint the leads, he took the terminal block apart and in replacing it mixed up the six leads. He was afraid to mention the mistake and, consequently, trouble developed when the motor was connected according to the diagram.

H. G. MILLICAN.
Kingston, Ont., Can.

Portable Gage for Determining Depth of Water in Wells

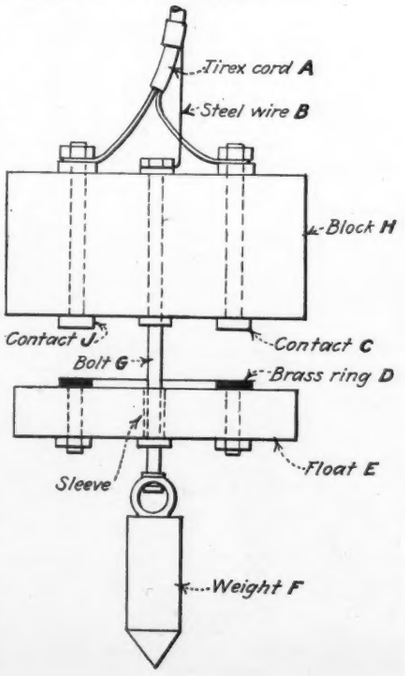
IN ORDER to operate efficiently the condensers in our plant, it is necessary to know the water level in the various wells that supply water to the condensers. So far, we have employed successfully only one method of determining the water level in these wells.

This method involves the use of a float equipped with suitable contacts, which is lowered into a wellcasing until an alarm bell rings. The ringing of the bell indicates that the device has been lowered to the water level.

Referring to the diagram the body of the device that is lowered into the casing is made in two parts, *H*, and *E*. The float, *E*, is guided by a bolt, *G*, so that when the device is lowered to the water level, the water raises the float until the brass ring, *D*, short-circuits the contacts *C* and *J*. When these contacts are short-circuited, current flows through the Tirex cord, *A*, to the signal circuit. In order to keep the device in an upright position a weight, *F*, is hung on the lower end of the bolt, *G*.

As the steel suspension wire, *B*, is graduated in feet and inches, the depth of the water level from the top of the casing can be read directly when the bell rings.

This diagram shows the construction of the water-level gage.



CHAS. A. PETERSON.
Chief Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

Equipment Record System

(Continued from page 419)

bearings in our motors were plain-bronze, grease-lubricated and in our service lasted generally from 3 to 6 months. They were a source of continual annoyance and expense. The expense was not limited to replacement of bearings but often extended to electrical trouble, with the consequent rewinding of armatures and field coils, and, in addition, the interruptions to operation.

About 5 years ago one of the 25-hp. crane motors was arranged for ball bearings, as an experiment, with housings of our own design. After it had been in service 21 months, it was taken down for examination and found to be in excellent condition. It was returned to the crane so we proceeded to install ball bearings on other motors. To date, about 30 crane motors have been changed over to ball bearings. Some of these have been in service 3 years and are still in service. We have had no trouble worth mentioning. These cranes are in service practically 24 hr. a day and make hundreds of lifts.

These motors, which formerly were a source of continual worry and expense, are now the least of our worries. A comparison of life of a few months for sleeve bearings with a number of years for ball bearings has convinced us as to which is better, at least for our service. We made the mistake of installing ball bearings which were over-rated for the job, but they are giving us excellent service. The photograph at the beginning of the article shows one of these motors with the upper half of the frame removed.

No claim is made that our system is 100 per cent perfect or that it is the last word. In fact, it has many flaws, as we are finding, but we are correcting and improving it continuously; however, it is working with some measure of success and is presented here, with the hope that some who read this may get some hint or idea that may be of use to them. If this should be true my writing and your reading shall not have been in vain.

MECHANICAL MAINTENANCE OF *Power Drives*

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Babbitting in Bearing Seats for Ball or Roller Bearings

USE of ball or roller bearings, when rebuilding old equipment or when constructing new or special machinery, is often passed up on account of the cost, which is made up of two items: namely, the cost of the bearing itself and the cost of making the bored and capped seat for the bearing. This higher first cost often causes the anti-friction bearing to be thrown out on a design in favor of its less expensive, plain competitor, without regard to future service or to ease of renewals.

The benefits of anti-friction bearings at lowered cost may be secured by setting these bearings in babbitt seats. This makes an inexpensive mounting that is exceedingly durable on a wide range of machines, although not usable in all cases. The writer has mounted a number of Timken and New Departure bearings of No. 305 size and larger in this manner and feels sure that the construction is satisfactory because the machines have been out in use for some time and no complaints have ever been registered.

Recently, some special material-handling machinery was built in which the practice of babbitting in was followed. For example a gear box for one of these machines contains four bearings in a length of 12 in., as shown in *A*. Three of these bearings were inexpensive, commercial ball bearings, whereas the fourth was a Gurney ball bearing which takes both thrust and radial loads. Thus the easy running and cheap renewal qualities of ball bearings were secured at a minimum of cost.

Cored holes in the cast-iron case, *A*, allow the shaft to pass through with ample clearance. The bearings were set in larger recesses at the ends of these cored holes. The method of installation used was to have a plain shaft for babbitting purposes. On this shaft were placed dummies of the same size as the bearings. These dummies consisted of cast-iron collars *B* with setscrews in the hubs, which were placed at measured intervals along the shaft after the latter had been set inside the casing. Babbittrite was used for the dam and the shaft was positioned by measuring from machined surfaces on the case.

The case was heated and the babbitt was poured at a low temperature. Anchor holes for the babbitt were placed in openings in the cast-iron case to insure a tight fit of the babbitt in the casing.

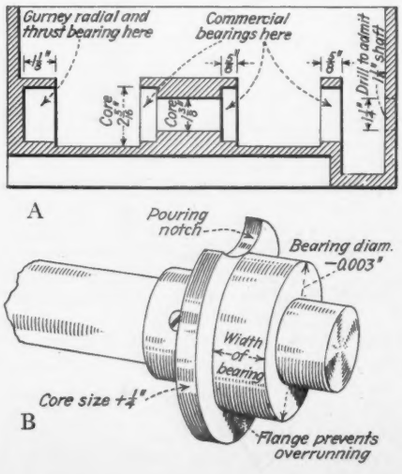
Upon removal of the dummies, the bearings were inserted. The collars were 0.003 in. smaller than the bearings, so that the bearings had to be squeezed into position. This holds the bearings tight and presses the babbitt back into the casting. A further advantage of the babbitt seat is that it makes possible the use of anti-friction bearings by shops that do not have boring facilities, because shafts can be placed without machine work. Also, it makes possible a last-minute change or a shift in position to make gear centers come better or parts engage as they need to be, as found necessary while assembling.

The drawing *A* shows the half gear case mentioned. The same size of core was used throughout, which lessens the pattern cost and leaves ample room for both makes of bearings. For manufacturing reasons, the end hole (where the shaft is put through) is drilled and can be plugged, if it is desired to run the gears in oil. The collar or dummy *B* may be left plain or made with a flange. The flange prevents overrunning and end-trimming after pouring and where more than one job is to be done, it will pay for itself.

DONALD A. HAMPSON.
Plant Superintendent
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Fixture for casting babbitt seats for ball or roller bearings.

Three commercial ball bearings and a Gurney radial and thrust bearing were to be placed in the gear box *A* of a special machine. The holes for the shaft and bearing were cored out and a mandrel fitted with flanged babbitting dummies *B* to cast seats for the bearings. This method of seating ball or roller bearings may be used on certain types of work at a saving in installation expense.



Recommendations for Applying Belt Dressings

WHEN a belt is bent around a pulley the internal fibers rub on each other. Unless the fibers are properly lubricated their resistance to wear is lessened, resulting in a shorter life, according to some information on belt operation, which was recently issued by Chas. A. Schieren Co. A suitable dressing provides the necessary lubrication to reduce this wear.

All belting should be dressed periodically. In very dry places it is good practice to dress a belt lightly every two or three weeks; in other places belts may need attention less often, depending on the service and amount of dressing applied. Many belt men apply a preservative dressing to the outer ply and allow the greases to penetrate through the leather. If the inside surface is very dry, a small amount is applied to this surface until it softens. By applying most of the dressing to the outside the surface never becomes slippery. It is not necessary to wait for a shutdown or week-end; but dressing can be applied while the belt is in operation, or at the noon period.

Applying the dressing to the outside of the belt is very good practice for belts operating in dusty places, such as flour mills, and so on. The application of a dressing to the outside, after brushing the dirt off, keeps the pulley surface from becoming gummed up. This keeps the belts in the pliable condition necessary for economical service.

Often the face of a cast-iron or split-steel pulley will become very shiny. This condition means that the belt is slipping and polishing the surface. Sometimes this condition requires the use of a larger belt. Leather belts that polish the face of the pulley do so because they have been allowed to dry out and become harsh and hard on the surface.

The application of a good belt dressing that will soften up the harsh leather surface will remedy this trouble. The shiny surface will disappear and a dull, smooth one take its place. It is this latter type of surface that is capable of transmitting heavy loads.

Use of Silent Chain Drive on Surface Grinder

THE management of a factory some time ago bought a surface grinding machine equipped with a magnetic chuck for their particular work, but no thought had been given to the details of how it was to be driven. The magnetic chuck required direct current for its operation, whereas only 60-cycle a.c. service was available.

In addition to this handicap the work in hand had to be ground dry but the machine was arranged for wet grinding, which is usually the case. The problem was eventually solved in an unusual manner, homely, but at minimum cost.

After the machine was received it was decided to change the location originally intended for it, which placed it out of reach of available line shafting. The first step was to remove the pump and its piping, leaving the upper part of the tank for a working surface upon which four flat bars of steel were laid and bolted down. The tank was cast integral with the base, having a ¾-in. wall that had been machined for a cover. A 5-hp. induction motor was installed with a slide base on two steel bars of the tank cover, allowing but 3½ ft. for pulley centers.

It was now readily foreseen that a pulley drive would be troublesome, so a Morse silent chain drive was ordered and installed as shown in Fig. 1 of the illustration. This chain drive, comprising a 23-tooth driving sprocket turning at 1,140 r.p.m. and a 48-tooth driven sprocket, has operated 9 hr. a day for five years, without the slightest expense or trouble.

The grinder was driven by the a.c. motor, but the Walker chuck requires direct current. A small generator and the necessary control is expensive; neither can such equipment be picked up at random in small towns, but someone suggested using a small dynamo that had been employed in experimental work. We found it to be an old Peerless dynamo rated at 1 hp. and 110 volts.

This equipment was very satisfactory, as the chuck required only 5 amp. at 110 volts. A slate switchboard was found and mounted on the grinder column, out of the way but with the voltmeter within the operator's line of sight, as shown in Fig. 2.

The generator was mounted on its pair of bars on the tank cover between the motor and the grinder column, directly in front of the switchboard panel.

Now by rearranging the feed belt drive a pulley was available for a take-off through which a 1½-in. belt could be run to the generator. As there was no sliding base with the generator, belt tightening was impossible. However, after it had been thoroughly proven that some means of taking up belt stretch must be provided, a tightener of the Lenix type was culled from the shelves and bolted to the dynamo. In order to keep down the surface speed of the idler pulley another pulley consisting of an old bronze bushing on which was pressed an impregnated wood bushing made by a New England firm was put on the stud.

This arrangement provided a quiet, slow-speed drive and to say the least, it is an interesting combination in which there is an a.c. motor and chain drive for the grinder, a d.c. generator with belt drive and tightener, and a wood-bushing idler pulley.

DONALD A. HAMPSON.
Plant Superintendent
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

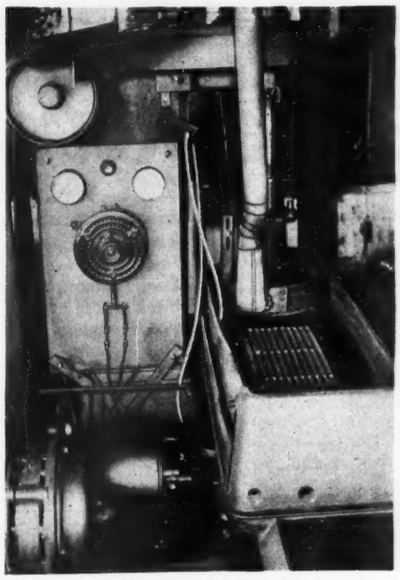


Fig. 2—This shows how the driving motor and direct-current generator were mounted on the tank which was part of the grinder.

Fig. 1—The grinder is driven by a 5-hp. induction motor through a silent chain.

There are 23 teeth in the driving sprocket, which turns at 1,140 r.p.m., and 48 teeth in the driven sprocket. The distance between shaft centers is 3⅔ ft. A Morse silent chain is used on this drive, which has operated 9 hr. a day for five years without trouble or expense.

Lubrication Insured by Control Devices and Warning Signal

AN interesting combination of control devices and warning signal has been installed by the Power River Co., Vancouver, Can., to prevent failure of the lubricating system on a large generator, and to prevent overheating of the generator thrust bearing. Upon failure of the main oil pump, a reserve pump is immediately started and a signal is sounded. The signal is also sounded when the thrust bearing overheats.

The oil pump, which is regularly used during the operation of the generator, is driven through gearing from the generator shaft. An independent motor-driven oil pump is also provided, with equipment for hand starting. Should the geared pump fail to operate, the motor-driven pump will go into service automatically.

This is accomplished by a General Electric pressure switch which is installed in the discharge side of the geared oil pump. With this arrangement, if the pressure of the geared pump drops, the pressure switch closes a magnetic switch, starting the motor-driven pump and sounding an alarm which operates on a 125-volt a.c. circuit.

The second pump, however, operates until normal conditions are restored and pressure is again being delivered by the geared pump, whereupon the contacts of the pressure switch open and the motor-driven pump is shut down.

The thrust bearing on the generator is equipped with a Tycos thermostat alarm control that operates a 125-volt, direct-current industrial signal when the temperature rises above a pre-determined maximum.

Owing to the fact that the contacts of the thermostat are designed for operation only in low voltage circuits it was necessary to employ a bell ringing transformer to supply the current for closing the small relay that connects the alarm signal to the 125-volt d.c. circuit. This simple system of control devices insures reliable and efficient lubrication at all times.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Simple Tests to Determine Condition of Medium-Sized D.C. Motors

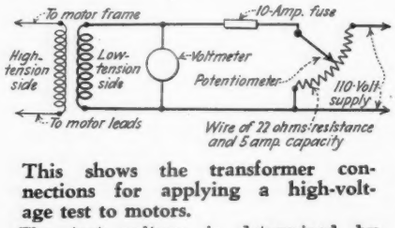
THE object of the simple tests that are to be described is to determine readily the condition of small and medium-sized d.c. motors, and to locate any weak spots that are likely to give trouble in the near future.

It is generally best to begin the examination of any motor by first inspecting the bearings. The condition of the bearings on the pulley end of the shaft may be determined by prying up under the shaft, or under the pulley if on the shaft, with a lever and in so doing the amount of play in the bearing may be noted. The condition of the bearing on the commutator end of a d.c. motor shaft can be determined by removing the end cap on the bearing housing, so that one can pry up under the shaft with a screw driver or a light bar, using the bearing housing as a fulcrum to pry on while observing play in the bearing. When the bearing lining projects out past the end of the shaft a 6-in. x 6-in. piece of wood may be used to pry on. Another method that might be employed to determine the amount of bearing clearance is to insert feelers or thickness gages between the shaft and the bearing lining. When a bearing is found with too much clearance, it should be inspected later on when the motor has been taken apart. The oil rings in the bearing should also be inspected to see if they turn freely and, if they do not, it will not take long for the bearing to burn out.

Next, it might be well to make a ground test on all of the windings. After connecting all the external leads together, a ground test can be applied simultaneously to the shunt and series fields together with the armature and brush rigging. A variable resistance connected as a potentiometer in the primary side of an ordinary single-phase transformer may be used to supply the test voltage, which should be increased gradually. If the coils appear to be in fairly good condition a test voltage of twice the normal motor voltage plus 1,000 volts may be applied for one minute.

The accompanying illustration shows how the voltmeter, small protective fuse, 110-volt supply line and the variable resistance should be connected to the primary side of the transformer. After the testing current has been applied, a zero reading on the voltmeter indicates a ground, and a ground is also indicated by the voltmeter reading falling to zero after the test current has been applied. The voltage of the test current may be determined by multiplying the voltmeter reading by the ratio of the transformer.

Before the motor is taken apart it might be well to give it a running test. A small, variable-voltage generator may be used to advantage to supply the test current, but if such a generator is not available a variable resistance may be used in series with the armature circuit in order to vary the test current. A low voltage should be applied to the motor at the start, and as the motor increases its speed the voltage may be gradually increased up to the rated voltage of the motor. While this is being done, the motor should be watched for sparking at the brushes, vibration noise, heating of the windings or bearings, and the no-load current reading should be checked with the rated no-load current marked on the motor nameplate.



This shows the transformer connections for applying a high-voltage test to motors.

The test voltage is determined by multiplying the reading on the voltmeter by the ratio of the transformer used.

If the various tests that have been applied so far indicate that the motor is in good condition, the motor may be taken apart. While applying a little less than the rated voltage, or the rated voltage, to the field coils when they are connected in series, a voltmeter reading should be taken across each field coil. The voltage drop across each coil should be the same and the sum of these voltages should equal the applied voltage. This procedure will determine whether or not the field coils are free from short-circuits or whether any of the coils are open. After the test current has been applied to the field coils, it might be well to check the coils with a compass for polarity. While moving the compass around the frame the successive poles should alternately indicate N and S.

While examining the condition of the armature, it is well to make a test for short-circuits in either the coils or between the commutator segments. One common way of checking the coils in the armature for short-circuits is by means of a growler. This is a laminated, two-pole magnet which is wound with a certain number of turns of wire, and is suitable for operation on an a.c. circuit. After placing the armature on the growler, a hacksaw blade or a thin piece of iron may be placed over the uppermost armature slots. A short-circuit will be indicated by the saw blade vibrating violently. If an ammeter is connected in series with the growler, an increase in current is indicated when the short-circuited coil is under the influence of the growler flux.

A millivoltmeter may also be used to check the condition of the armature by applying its terminals to two adjacent commutator segments. The commutator segments on either side of these two segments are energized from a dry battery, thereby causing a normal reading of the millivoltmeter when the coils are in good condition, a high reading when there is an open-circuit, and a low reading when there is a short-circuit. If a telephone receiver is substituted for the millivoltmeter, a normal buzz will indicate that the coils are OK., a loud buzz will indicate an open-circuit, and no buzz will indicate a short circuit.

Very often the brush-holder on a d.c. motor has been moved out of the neutral position, and when this mark cannot be found it is difficult to determine the neutral position of the brushes. To check the neutral position of the brushes on the commutator apply about one-half normal voltage to the shunt field, and while the terminals of a low-reading voltmeter or a millivoltmeter are making contact with two adjacent commutator segments, open the field control circuit and note the amount of deflection on the scale of the meter. There should be very little or no deflection when the meter terminals are making contact with the commutator at a neutral brush position.

A general inspection should also be made to note the condition of the brushes, brush shunts, condition of varnish and insulation of the field coils, and the bolts holding the field coils to the frame, to see that they are tightened up. The condition of the armature bands should not be overlooked, and the connections between the coil leads and the commutator bars should also be inspected. A continuous overload often causes the solder that holds the coil leads to the commutator bars to melt, and due to the centrifugal force of the armature revolving the melted solder is often thrown off, with the result that a silver-like line of solder sticks to the field frame or coils.

Los Angeles, Calif. E. LINDOP.

Quick Method of Stripping Closed Slot Armature

ORDINARY soda ash, which is comparatively cheap, can be used as a means of quickly stripping a closed-slot armature. Before soaking the winding in the boiling solution of soda ash (also lye and Oakite can be used for this purpose), the commutator should be removed or pains be taken to cover it and keep it out of the solution, if the commutator is in good condition. But when it is necessary to remica the commutator, the whole armature can be submerged in the solution in this case.

To hold the armature, put a lathe dog on the commutator end of the shaft and either dip the armature until the winding is submerged or hang the armature over the tank and pour the solution over the winding.

After an armature has been stripped by this method, it must be well dried by baking in order to drive out all moisture between the laminations. When the new winding is in place, the armature should be dipped and baked.

As dipping and baking is common practice today, this process will fill the space between the laminations with varnish. So it is obvious that any armature handled by this method will not heat up on account of the solution removing some insulation between the laminations because these spaces between the laminations will be filled again during the varnish dip. The ash solution in addition to removing the coils will also clean out the air ducts, thus improving the ventilation of the machine.

A. C. ROE.

Renewal Parts Engineering Dept.
Westinghouse Electric & Manufacturing Co.,
East Pittsburgh, Pa.

How to Care for a Blow Torch

FEW tools receive such hard service or so little care as a blow torch, yet it is not difficult to keep them in good condition. When in use, they are operated at a very high temperature that expands the metal of which the burner is made. For this reason do not close the needle valve tightly after the flame has been extinguished because upon cooling the contraction of the metal will in this case cause the needle hole to be gradually enlarged and cause trouble.

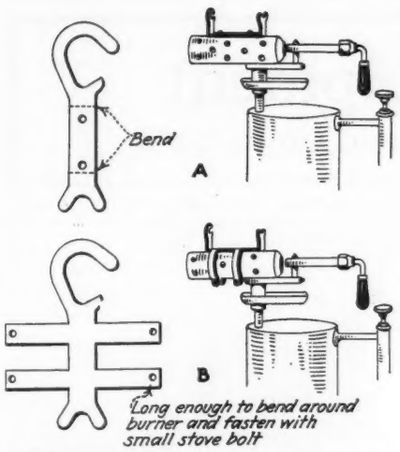
Asbestos cord with a small amount of graphite makes a satisfactory packing for the glands, which should be kept tight enough to prevent leakage. The pump leather should be oiled occasionally with a vegetable oil in preference to a mineral oil, as the latter will harden the leather. The check valve will seldom require any attention except possibly through renewal of the cork.

The practice of excessive pumping of air into the reservoir is quite common, but should not be done because operating the torch with a high pressure in the reservoir is dangerous.

Most torches, when new, are equipped with a device to hold a soldering iron in place over the flame. These hooks frequently break off, but when this happens they can be readily replaced, as indicated in the accompanying diagrams. To do this take a piece of heavy sheet iron and bend it as indicated at the dotted line in the diagram, and then fasten it to the burner by means of two machine screws as shown in *A*. The hook shown in *B* is the same, except that two straps have been added which are turned under the burner and fastened with small stove bolts as shown in the illustration.

C. A. P.

Fairbanks, Alaska.



This shows how an iron holder is fastened to a blow torch.

Simple and Inexpensive Type of Appliance Test Panel

IN OUR shop we have six 110-volt test panels in daily use which have covered our needs in the repair of appliances, etc., for many years past.

The panel is 8 in. x 10 in. over-all and is made of $\frac{1}{4}$-in. asbestos on a $\frac{7}{8}$-in. board backing. The fuse blocks, switches and receptacles are mounted on the asbestos as shown in the illustration.

The upper receptacle *D* is wired in series with *A* and *B*, across the terminals of the double-pole knife switch. The double T-slot plug receptacles at *A* and *C* can be placed across the line when both knife switches are closed. The receptacle at *B* is for the occasional appliance or cord with a non-separable plug.

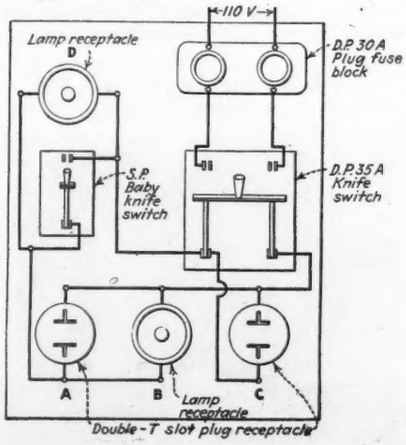
Most of the time a lamp is kept in receptacle *D* to facilitate short-circuit or open-circuit tests on appliances plugged in at either *A* or *B* and the full line voltage is applied by closing the single-pole knife switch.

Receptacle *D* may be used to accommodate an ammeter when it is necessary to determine current consumption and by utilizing the potential from receptacle *C*, wattmeter tests may be given.

GARSON A. REESE.

Manchester, N. H.

This 110-volt test panel simplifies appliance repair work in the shop.



Emergency Repair of Defective Generator Field Coil

WHILE I was in charge of the electrical equipment in a plant where 200 men were employed in fabricating steel and producing castings, the failure of a 75-kw., 230-volt, d.c. generator supplying only 25 per cent of the plant load caused the entire plant to shut down one day at 5 p.m. Three-phase, 440-volt power was used on 75 per cent of the machinery, but due to an old installation of d.c. cranes, upon which the entire plant depended, it was necessary to generate d.c. power for their operation.

A hasty examination showed the main fuses to be intact, and after a short time the trouble was found in one of the field coils.

The generator field coils were pyramid-shaped in order to use a large number of turns of wire and still have the coils fit in the available space. The defective coil was removed after a test showed it to be open.

The field coil and polepiece were chucked in a lathe to enable us to remove the winding. A measurement showed that the wire was square, but square wire of this size was not kept on hand. A telephone call to a large electrical house in a city 30 miles away found no one on hand except a night watchman. The electrician, in the meantime, was instructed to remove the wire from the coil by hand; so a helper slowly revolved the lathe head by pulling on the drive belt.

At 11 p.m. the supply-house promised to forward the necessary wire by messenger. The "open" in the field coil was found about this time. It was 210 turns from the starting end. At 1:15 a.m. the messenger arrived with the wire, which was carefully attached to the undamaged section by means of a copper sleeve and hard solder. The coil was then rewound in accordance with our notes and at 4 a.m. it was replaced in the generator.

A short run showed that all was in perfect order and ready for operation when the men came in at 7 o'clock.

CHAS. A. PETERSON.

Chief Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Electrically Driven Handsaw

THE addition of the Kwicksaw, an electrically-driven handsaw, to its line of woodworking machinery has been announced by The Porter-Cable Machine Co., North Salina and Exchange Sts., Syracuse, N. Y. The Kwicksaw weighs 10 lb. and can be operated with one hand.

The saw is mounted directly on the special motor armature, that runs on ball bearings packed with grease. The wide supporting shoe carries the weight of the tool, prevents tipping, and aids in securing square cuts, it is claimed. By loosening the front handle, the hinged supporting shoe can be set for any depth of cut up to 2 in.

Standard equipment consists of 10 ft. of rubber-covered conductor cable with an armored duplex plug and one 7-in.

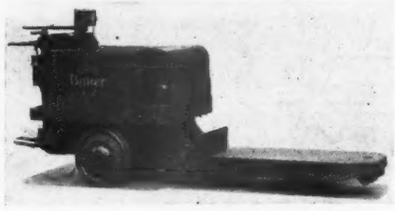
Kwicksaw Manufactured by Porter-Cable Machine Co.

combination saw which may be used for both ripping and cross cutting. A universal motor wound for 110 or 220 volts, as specified, which will operate on direct current or alternating current of 25 to 60 cycles, is used.

Elevating Truck

ANNOUNCEMENT has been made by the Baker-Raulang Co., Cleveland, Ohio, of its new Series E elevating trucks. During the elevating operation the platform is pulled up four inclines by two roller chains. The platform travels a maximum of 9 in. with a net lift of 6 in.

An inclosed magnetic disk brake mounted on an extension of the armature shaft brings the motor to rest after the limit switch operates. The control switch for the elevating motor is mounted on the dash where it is accessible. By manually operating this switch the hoist may be stopped at any point and started up again or reversed as desired. It is not necessary to go through the entire cycle of operations to complete the lifting or lowering movement.



Baker-Raulang 3-ton, Series E Elevating Truck

The automatic switch is interlocked with the controller and brake pedal so that it is said to be impossible to operate the truck except by a conscious and sustained movement on the part of the operator.

The frame is fabricated from structural steel and the other parts of this truck are Baker inter-standardized units. The trailing axle consists of an alloy steel forging and each wheel turns on an individual knuckle and is fitted with two Hess-Bright, radial ball bearings.

These trucks are built in different sizes to accommodate weights of 3 tons, 5 tons, and 10 tons, respectively.

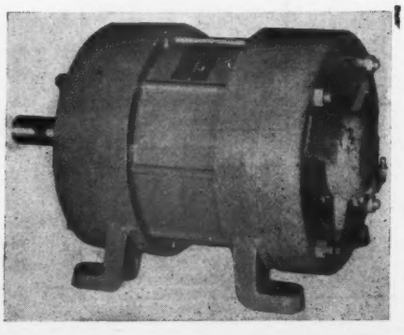
Steel Induction Motor

A COMPLETE line of all-steel, ball-bearing, polyphase induction motors, ranging in size from 1 to 100 hp. in all standard voltages and cycles, is announced by the Lincoln Electric Co., Cleveland, Ohio. Hot-rolled steel has in these motors entirely replaced the grey iron and malleable castings which were formerly used.

It is claimed that every part of the motor is at least twice as strong as the former type which was built with a cast-iron frame. Drop-forged steel feet are welded onto the hot-rolled steel end rings of the motor. The end brackets or bearing supports are also made up of welded steel construction.

Less thickness of material is required in the frames of the new motors and, it is claimed, the increased ventilation so obtained results in a considerable increase in the overload capacity of the motor; so that a continuous overload of from 10 to 50 per cent can be handled by the motors, depending upon the size and speed.

Lincoln Electric Co. All-Steel, Ball Bearing Induction Motor

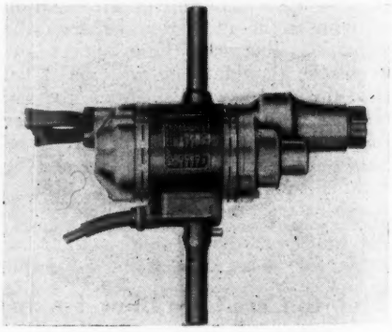


Universal Drill

ADDITION of a standard-duty, ⅞-in. capacity universal drill to its line of electrical tools has been announced by The Hisey-Wolf Machine Co., Cincinnati, Ohio.

The motor has ball bearings which are said to be fitted in such a way as to eliminate slip and creeping action. The gear on the armature shaft is removable.

The drill spindle, which is of liberal dimensions, is hardened and ground, and is automatically lubricated through the gear case. It is fitted with a No. 2 Morse taper socket.



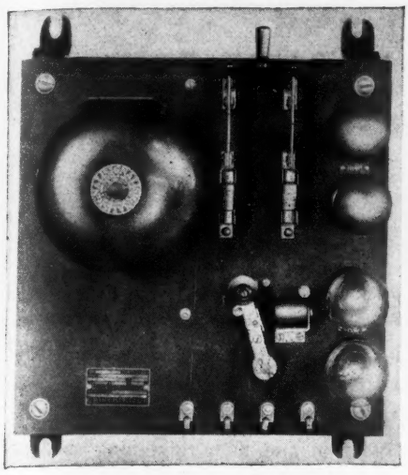
Hisey-Wolf ⅞-in. Universal Electric Drill

In order to provide brush adjustment when necessary, the brush holders are mounted as a separate unit on a Bakelite yoke. The drill weighs 25 lb.

High-Low Water Alarm Signal Panel

A NEW signal panel has been designed for use with pump installations, especially in buildings, by the General Electric Co., Schenectady, N. Y. This warning signal, known as the CR-4779-A-1, is for the purpose of calling an attendant in case of danger from overflow or emptying of the tank.

The panel is governed by one or two float switches, and an audible signal sounds immediately when either the predetermined high or low level of water is reached. The gong can be silenced by the attendant upon his arrival, and the silencing switch does not have to be manually reset after the float switch takes a normal position. High and low signal lamps are provided, either of



G. E. High-Low Water Alarm Signal Panel

which lights when the predetermined level has been reached, remaining lit until the float takes a normal position.

The panel can be used for a one-level signal by omitting the float switch for the other level. It can also be used on pressure systems but, when single-pole float or pressure switches are used, it is necessary to add a relay in place of the other pole.

Hydraulic Jacks

ANNOUNCEMENT has been made by the Blackhawk Manufacturing Co., Milwaukee, Wis., of the marketing of a complete line of hydraulic oil-power jacks, ranging from a 1½-ton model to a 75-ton industrial unit. Although these jacks have been made and distributed under another name on the Pacific Coast for the past five years, they have been further improved and standardized by the Blackhawk Co.

The Twin-Chek valve unit, a patented feature, is located below the pump, and in an easily accessible position for removal for cleaning or replacement.

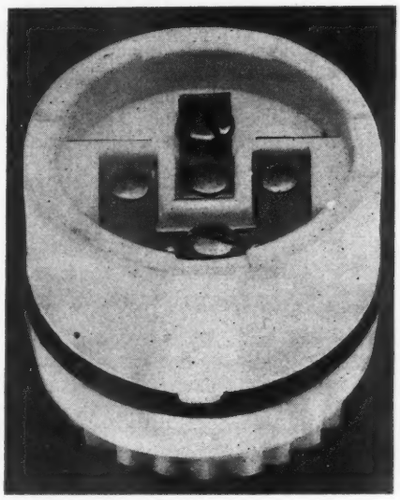
Lowering is done automatically with a controlled release valve; the speed is governed by the operator. The handle of the jack, in addition to being used for lifting purposes and for placing the jack at long range, is used to open the release valve for lowering, to control the drop, and to withdraw the jack.

The complete line of Blackhawk hydraulic oil-power jacks consists of ten models in nine capacities. The 18-ton, model E-14 unit, illustrated, weighs 60 lb., is 14 in. high, and has a lift of 8¼ in., which gives a total height of 22¼ in. when extended.

Blackhawk 18-ton Hydraulic Oil-Power Jack

Porcelain Receptacle

ANNOUNCEMENT has been made by the C. D. Wood Electric Co., Inc., 565 Broadway, New York, N. Y., that they have added to their line of electrical wiring devices a two-piece porcelain receptacle for ceiling fixtures, outlet boxes, and sign work.



Wood Two-Piece Porcelain Receptacle

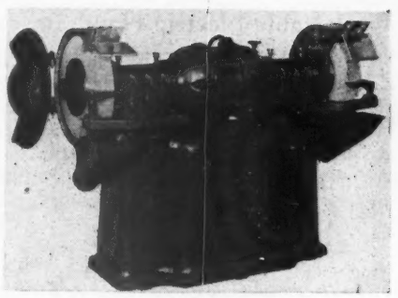
This receptacle, designated as No. 444, has the terminals recessed and entirely enclosed on the sides so that the receptacle may be sealed up and made weatherproof, after the wires are fastened to the terminals. The recess is made deep enough to cover the heads of the screws, which are polarized.

Electric Grinder

A HEAVY-DUTY, electrically driven grinder which is made in 5-, 7½- and 10-hp. capacity respectively, has been added to the line manufactured by the Standard Electrical Tool Co., Cincinnati, Ohio. The 5-hp. grinder carries two wheels, each 18 in. in diameter with 3-in. face and 2-in. bore, and weighs 1,920 lb. The 7½-hp. grinder carries wheels 24 in. in diameter with 4-in. face and 2½-in. bore, and weighs 2,020 lb. The 10-hp. grinder carries wheels 24 in. in diameter, with 4¾-in. face and 2½-in. bore, and weighs 2,375 lb.

These grinders are equipped with General Electric push-button control and 40-deg. General Electric motors fitted with four SKF deep-grooved ball bearings incased in dustproof chambers. The armature shaft is provided with a locking device to be used when changing wheels.

The emery wheel guards are of the hinge-door type with exhaust connections. Each guard is fitted with a spark breaker as well as a polished, wired-glass eye shield.



Heavy-Duty, Electrically Driven Grinder, Made by Standard Electrical Tool Co.

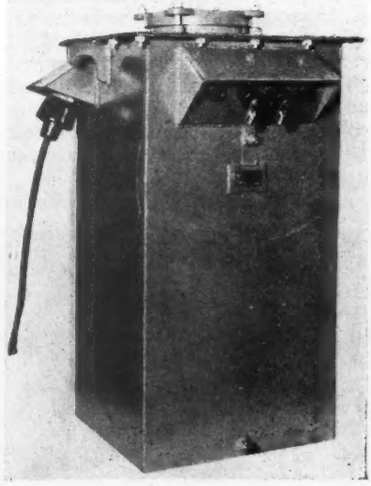
Distribution Transformers

NEW distribution transformers for industrial application, which are designed and constructed to operate under severe conditions of vibration and handling, have been introduced by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. These transformers, known as Types SB and SKB, have extra-heavy bracing to protect the coils and iron in the tank. The transformers may be made absolutely oil tight, it is stated.

Two important applications of these transformers are in the oil fields and in mines. It is claimed that these transformers may be transported on their sides without injury or danger of any oil leaking or splashing out.

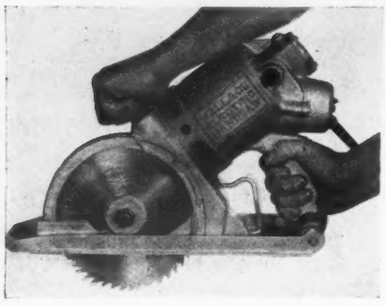
They can be safely used on electric shovels, trucks, railway cars and other equipment where unusual vibration is found.

Westinghouse 25-kva. Distribution Transformer



Portable Electric Handsaw

ANNOUNCEMENT is made of the addition of an electric handsaw to the line of portable woodworking machinery manufactured by J. D. Wallace & Co., 2808 Wilcox St., Chicago, Ill. A



Wallace Portable Electric Hand Saw

universal type of ball-bearing motor of standard make is used to drive the saw spindle, and the gears run in grease. An 8-in. standard round-hole saw blade is the largest size that can be used.

In operation the safety guard is released by means of a trigger conveniently placed near the grip. When the cut is finished and the saw is lifted from the work, the safety guard or shoe automatically drops and locks in position, covering the blade.

A splitter follows the saw blade, drops into the cut, and helps to guide the machine. An indicator in front makes it possible to follow a line, and the shoe is machined on one side to follow a guide rail.

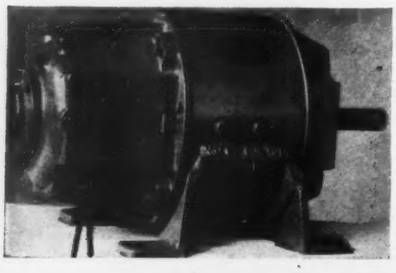
With the depth gage which is provided, the saw can be set to cut to any predetermined depth.

Hoist Motor

A NEW motor has been developed by the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., particularly for use on portable type room hoists in mines. Across-the-line starting is permitted with negligible disturbance at the commutator on this type RH, totally enclosed motor, rated at 5 hp., 15 min., 55 deg. C. temperature rise, 1,150 r.p.m., compound wound, 115, 230 or 550 volts.

The armature coils are so constructed and installed that a single coil can be replaced with a minimum disturbance of the other coils. In addition to each coil being specially insulated, the shunt and series coils for one pole are assembled as one unit and then dipped and baked in this form, special precautions are taken to insulate the coils from each other and from the ground.

New Westinghouse Type RH Motor.

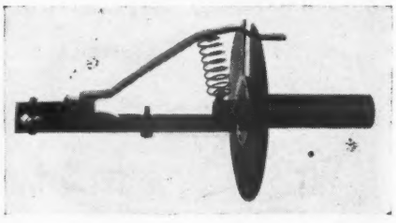


The RH motor is rugged in construction, having a rolled steel frame and drop forged steel feet that are welded to the frame. The bearings are of the heavy duty roller type and the motor can be operated in an inclined position. The inclosing covers are hinged to the bracket and can be raised for inspection of the brushes and commutator by loosening one screw. There are a total of four covers, giving easy access to these parts.

Electrode Holder

A HOLDER for metal electrodes has just been introduced by the Lincoln Electric Co., Cleveland, Ohio. This 600-amp. holder, known as Type TR, handles an electrode as large as ¼ in.

Many improvements are claimed for these holders which have replaceable copper jaws, four-line contact for electrodes, and an all-copper path for the welding current. They are made of structural steel for maximum strength and light weight, and are well balanced. These holders have an insulated and ventilated handle and shield for protecting the operator's hand.



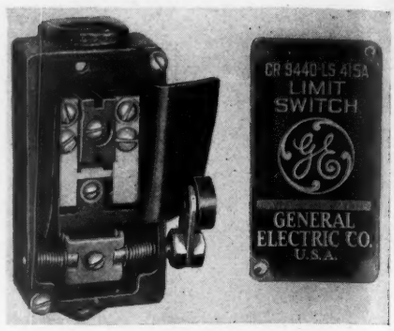
Lincoln Electric Co. 600-Amp. Metal Electrode Holder

Limit Switch

A SMALL limit switch has been designed by the General Electric Co., Schenectady, N. Y., to meet the requirements of the machine tool industry and other manufacturers for their control circuits. This switch can be used for stopping carriages at the end of the travel, bailing machines, door-opening limits and for other applications where normally-open or normally-closed contact is required.

The switch is cast iron, is arranged for conduit connection and is designed to be dust-tight. The contacts may be either normally open or normally closed, although the switch as shipped by the manufacturer is normally closed. To change over for normally-open operation requires but the removal of a few screws, the reversing of a finger block and the replacing of the screws.

The operating arm of the switch can be set at any angle by loosening the nuts on the operating shaft, adjusting the arm and then tightening the nuts. If it is desired to use the operating arm on the other side of the switch, a form can be furnished with the arm mounted on that side.



Small Limit Switch Manufactured by the General Electric Co.

The following ratings are given to cover the switch, providing it is opened approximately ¼ in: 2 amp. at 125 volts, 1 amp. at 250 volts, and 0.4 amp. at 600 volts.

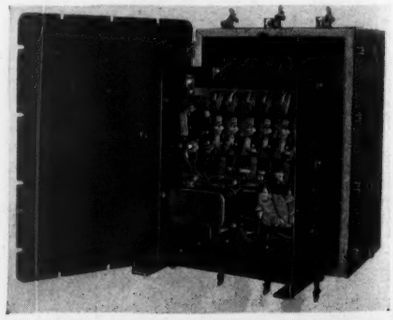
Dust-Tight Compensator

A SMALL automatic compensator has been designed by the General Electric Co., Schenectady, N. Y., to be used in places where dust is prevalent as in grain elevators, coal crushing plants, and other similar places. This device is for low voltage, and is inclosed in a boiler plate case. The compensator has been given the General Electric designation CR-7051-J-2.

A standard automatic compensator is used in the construction, but the usual conduit box, wall support and top and front covers are omitted. The boiler plate case in which it is enclosed is made up as a unit with angles on which the compensator may be slid in or out. When the compensator is in position the angles can be raised to a vertical position, thus allowing the front door to close.

The boiler plate case is made up of ¼-in. plate. The front cover is held down by 14 wing nuts and clamps against a vellumoid gasket on the case. An extra cable clamp is furnished with the compensator to hold the cables and to take the strain off the terminal board when the compensator is put into and taken out of the case.

Small G. E. Dust-Tight Compensator.



Practical Books
for your personal library

Every man who aspires to larger responsibilities should build up a professional library containing carefully selected volumes on subjects related to his work. Copies of the books which are reviewed here may be obtained from the publishers mentioned.

NON-TECHNICAL CHATS ON IRON AND STEEL—By LaVerne W. Spring, Chief Chemist and Metallurgist, Crane Co. Published by Frederick A. Stokes Co., 443 Fourth Ave., New York, N.Y. Cloth; 5½ x 8 in.; 465 pages; 342 illustrations. Price $4.

The present volume is the second edition of this work, which has been brought up to date by the incorporation of considerable new matter and the revision of much of the material in the first edition.

The purpose of the book is to present in a simple way, that is authoritative and yet free from hard-to-understand technicalities, the more important facts relating to the metallurgy of iron and steel. Beginning with an interesting chapter on the early history of iron and iron working, the raw materials used in smelting iron are discussed. This is followed by a description of the construction and operation of the blast furnace and the processes employed in producing wrought, cast and malleable iron, alloy and high-speed steels, and so on. The processes involved in the manufacture of wire, rods, pipe and other products are discussed in separate chapters. The crystal structure of iron and steel under different conditions of treatment is well illustrated by many micro-photographs.

The layman who would like to know more about the manufacture and properties of the most useful metal known to man will find this book admirably suited to his purpose.

REPAIR SHOP DIAGRAMS AND CONNECTING TABLES FOR INDUCTION MOTORS—By Daniel H. Braymer, Consulting Engineer, and A. C. Roe, Industrial and Insulation Engineer, Renewal Parts Engineering Department, Westinghouse Electric & Manufacturing Co. Published by McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N.Y. Cloth; 6 x 9 in.; 232 pages, 210 illustrations. Price $2.50.

The object of this book is to furnish repairmen and armature winders with practical step-by-step instructions on laying out of coils for induction motor windings and connecting the coil groups in proper sequence for different types of windings used in two- and three-phase motors having from 2 to 24 poles. The information presented can also be used when reconnecting the coil groups to satisfy changes in voltage, number of phases, frequency, or speed.

Each diagram in this book is a practical shop drawing, the proper connections for the ends of all phase groups of coils being indicated so that they can easily be followed by the winder when making the connection. In addition, the diagrams are accompanied by tables that give the number of coils in the different phase groups and the markings for the ends of these groups as indicated in the diagrams, to show the differences in marking for the ends of phase groups in various types of windings.

STANDARD WIRING—For Electric Light and Power—By H. C. Cushing, Jr. Published by H. C. Cushing, Jr., 15 West 55th Street, New York, N.Y. Leather; pocket size; 496 pp.; 391 illustrations; 91 tables. Price $3.

In the 1927 (33d Edition) of Cushing's "Standard Wiring for Electric Light and Power" the author has endeavored to set forth the essential requirements for safe and efficient wiring and construction for electric light, heat, and power. Every suggestion and recommendation is in accordance with the latest edition of the National Electrical Code and the latest engineering practice. There are many explanatory and helpful notes, illustrations, definitions, and tables for the guidance of the man who does the work.

This handbook covers the subjects of inside and outside wiring, generators and motors, storage batteries, illumination, and special types of wiring such as in garages, theatres, moving picture houses, electric range, heater, and radio wiring. Among the added features in this 1927 edition is a complete treatise on the "Red Seal" wiring plan, giving complete specifications, and new chapters on illumination and house wiring.

This well-known manual seems to become more useful and usable with each new edition.

UNDERGROUND SYSTEMS FOR ELECTRIC LIGHT AND POWER—By T. C. Ruhling, Vice-Chairman, N.E.L.A. Underground Systems Committee. Published by McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N.Y. Cloth, 6 x 9 in.; 346 pages; illustrated. Price $4.

This book had its beginnings in a few cost records which the author made in the course of his work on underground electric conduits. These notes were later expanded into articles that appeared in various technical journals.

The scope of this book is well indicated by the following chapter headings: Underground Conduit Construction; Laying Fiber Conduit; Tile-Duct Construction; Manhole Construction; Underground Construction Cost Data; Transmission and Distribution Conduits; Underground Transmission and Distribution; Underground Cable Installation; Underground Street-Lighting Systems; Installing Submarine Cables; Cable Splicing; Fireproof Underground Cables; Fault Location.

Out of his wide experience in underground work the author has produced a treatise on this subject that will be of interest and value to engineers, construction foremen and all others who are concerned with the layout and installation of underground electrical systems.

SWITCHING EQUIPMENT FOR POWER CONTROL — By Stephen Q. Hayes, General Engineer, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Published by McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N.Y. Cloth, 6x9 in.; 556 pages; illustrated. Price $5.

The present volume is the second edition of this book, and has been made necessary by the important developments and changes in both design and practice in the application of switching equipment that have been made during the past few years.

Owing to the comparatively recent introduction of European switching equipment it was deemed desirable to include in this edition a description of certain European equipment and practices that appear likely of adoption in this country.

The arrangement of the subject matter has followed the plan of first describing switching equipment in the order in which the various devices were developed. This is followed by a discussion of the main connections desired in a power plant and the methods of obtaining the maximum reliability and safety with the minimum outlay. Switchboard panels, control desks, and the like, are considered next, with the location of the circuit breakers, bus structures and other equipment, and the general arrangement of that part of the power plant devoted to switching equipment.

The main object of the book is to give the switchboard operator information that will help him to keep the equipment in his care in the best operating condition, by explaining its functions and capabilities.

This book will also help students of electrical engineering to obtain a better understanding of the relations between the switching equipment and the apparatus which it controls.

Consulting engineers and operating men will find in it information that will give them an understanding of the functions and limitations of the various devices treated and facilitate the selection and application of equipment that is suitable for the service requirements.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

STEEL SHELVING—Circular No. 1277, recently issued, describes and illustrates the Universal line of steel shelving and cabinets.—Universal Fixture Corp., 135 W. 23d St., New York City.

HYDRAULIC JACKS—"The Big Lift for Your Business" is the title of the brochure which introduces the Blackhawk line of hydraulic oil-power jacks. These jacks are made in several styles with capacities ranging from 1½ to 75 tons.—Blackhawk Manufacturing Co., Milwaukee, Wis.

TRANSFORMERS—An illustrated description of Wagner HE type of single-phase distribution transformers and tables of dimensions and capacities are contained in Bulletin 148.—Wagner Electric Corp., St. Louis, Mo.

DIRECT-CURRENT MOTORS — Bulletin 200 describes and illustrates Reliance Type T heavy-duty direct-current motors.—Reliance Electric & Engineering Co., Ivanhoe Road, Cleveland, Ohio.

THREADLESS FITTINGS—A series of folders has been issued describing and illustrating the Kondu boxes and couplings manufactured by this company—Erie Malleable Iron Co., Kondu Division, Erie, Pa.

MAGNET WIRE—Catalog No. 27, covering the entire line of Maring magnet wire is now being distributed by this company. It contains tables, data and other helpful information for magnet wire users.—Maring Wire Co., Muskegon, Mich.

DIE STOCKS—Booklet No. 19 contains an illustrated description of the Beaver line of die stocks, pipe cutters and power drives.—The Borden Co., Warren, Ohio.

FILMS—The Gas Products Association has recently completed two reels of films illustrating the oxy-acetylene welding and cutting process. A limited number of prints of these films are available and may be had by making application to the association secretary. —Gas Products Association, 140 So. Dearborn St., Chicago, Ill.

WORM GEARS AND DRIVES—Bulletin E devotes 32 pages to an explanation of the construction and application of data on Type WT Fawcus Timken-bearing worm-drive speed reducers. Several pages are devoted to engineering data including dimension outlines, ratios, efficiency and horsepower ratings of these units.—Fawcus Machine Co., Pittsburgh, Pa.

PORTABLE ELEVATORS—Bulletin 90C describes the new model M silent-chain spur-gear drive as applied to electric portable elevators.—Revolvator Co., 336-352 Garfield Ave., Jersey City, N. J.

ELECTRIC HEATING — Catalog C describes and illustrates electric heat control and resistor units manufactured by this company.—Acme Electric Heating Co., 1207-1223 Washington St., Boston, Mass.

FLEXIBLE COUPLING—Bulletin 627 illustrates the construction and operation and gives ratings and dimensions of the new Nicholson all-metal, lubricated flexible coupling.—W. H. Nicholson & Co., 12 Oregon St., Wilkes-Barre, Pa.

ELECTRIC HOISTS—The 28-page bulletin 71-A is an illustrated and descriptive catalog of Shepard floor-operated electric hoists.—Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.

WELDED PIPE LINES—A well-illustrated booklet describes a number of long pipe lines with Oxwelded joints.—The Linde Air Products Co., 30 E. 42nd St., New York, N. Y.

INSULATING COMPOUNDS. — Bulletin 696 is a supplementary catalog giving the characteristics and uses of various Mitchell-Rand insulating compounds.—Mitchell-Rand Mfg. Co., 18 Vesey St., New York, N. Y.

CARBON BRUSHES.—An 11-page illustrated catalog gives a description and instructions for ordering Carenco brushes for motors and generators.—Carbon Engineering Co., Eighth Ave. & Morgan St., Milwaukee, Wis.

AIR-COOLED TRANSFORMERS — Bulletin 527 illustrates the various types and gives specifications together with wiring diagrams for Trester air-cooled, dry-type transformers for lighting and other similar service.—Trester-Service-Electric Co., 55 E. Wells St., Milwaukee, Wis.

SPEED REDUCERS—Catalog 26 devotes 96 pages to illustrating numerous applications and to giving dimensions and other engineering data regarding the Jones spur gear and worm gear speed reducers.—W. A. Jones Foundry & Machine Co., 4430 W. Roosevelt Road, Chicago, Ill.

GROUND RODS — A folder gives the advantages of using Copperweld ground rods and ground wire attachments for permanent, low-resistance earth grounding.—Copperweld Steel Co., Braddock P.O., Rankin, Pa.

OUTBOARD BEARINGS—A circular describes and lists the sizes of the new standardized, adjustable outboard bearings manufactured and distributed by this company. — Boston Gear Work Sales Co., Norfolk Downs, Quincy, Mass.

FIRE EXTINGUISHER—A circular describes the F-R-X gallon type carbon tetrachloride fire extinguisher for electrical and other fires. This unit contains a pressure tank for discharging the extinguishing liquid. — Foamite-Childs Corp., Utica, N. Y.

FACTORY TRUCKS — A circular describes and illustrates a line of four-wheel box, open-side, and flat-top steel trucks manufactured by this company.—Angle Steel Stool Co., Plainwell, Mich.

CRAWLER — Bulletin B-10 illustrates applications and construction features of the Link-Belt all-purpose crawler which can be converted and used with shovels, drag-lines, cranes and so on.—Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill.

CONDULETS—Folder 50 illustrates and gives the various types of the new Crouse-Hinds Obround Form 7 condulets and condulet fittings with Wedge-Nut fasteners. — Crouse-Hinds Co., Syracuse, N. Y.

SPEED CONTROL—A circular covers the Reeves electric remote control speed regulation for the Reeves variable speed transmission unit.—Reeves Pulley Co., Columbus, Ind.

UNIT HEATER — A 16-page catalog illustrates the construction of the hiJet unit heater with the Wedge Core radiator and engineering data for their selection and installation.—The Herman Nelson Corp., Moline, Ill.

POWER TRANSMISSION — A recent issue of *The Labor Saver*, distributed monthly by this company, describes the construction and operation, illustrates applications, and gives engineering data on the JFS variable speed transmission and the S-A Speeducer spur-gear speed reducer. — Stephens-Adamson Mfg. Co., Aurora, Ill.

INSULATING VARNISH — A 12-page illustrated booklet discusses the use of insulating varnish for impregnating coils, with helpful suggestions on how to use it. — John C. Dolph Co., 168 Emmet St., Newark, N. J.